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## CONTENTS OF THE NUMBER FOR FEBRUARY 1937.


| CONTENTS. | Page. |
|---|---|
| I. **Effects of the world crisis and road competition on the railway position. Corresponding changes in railway commercial policy** (Subject X, 13th Congress). Report (*Four main-line railways of Great Britain — affiliated to the International Railway Union (U. I. C.) — and main-line railways of all other countries, not affiliated to the International Railway Union*), by Mr. ASHTON-DAVIES. . . . . | 309 |
| II. **The construction of modern track to carry heavy loads at high speeds, and methods of modernising old track for such loads and speeds. Facing points which can be taken at high speeds** (Subject I, 13th Congress). Report (*Germany, Austria, Belgium and Colony, Denmark, Finland, Hungary, Luxemburg, Norway, Netherlands and Colonies, Poland, Sweden, Switzerland*), by C. LEMAIRE. . . . . | 357 |
| III. **Selection, orientation and instruction of railway staff** (Subject XI, 13th Congress). Report (*Czechoslovakia, France and Colonies, Belgium and Colony, Luxemburg, Switzerland, Austria, Hungary, Jugoslavia, Bulgaria, Rumania, Greece, Turkey*), by J. HONDL . . . . . | 443 |
| IV. Note on **train speeds.** — II. **Train speeds and services in different countries,** by Lionel WIENER (*continued*). — XIX: **Spain and Portugal** . . . . . | 479 |
| V. MISCELLANEOUS INFORMATION: **4-6-2 streamlined express passenger locomotive « Golden Eagle »**, L.N.E.R. . | 500 |
| **Resignalling of the Northallerton-Darlington line** . . . . . | 500 |
| VI. MONTHLY BIBLIOGRAPHY OF RAILWAYS . . . . . | 13 |

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[ 656. ]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

QUESTION X.

# Effects of the world crisis and road competition on the railway position. Corresponding changes in railway commercial policy.

## REPORT

*(Four main-line railways of Great Britain — affiliated to the International Railway Union — and main-line railways of all other countries, not affiliated to the International Railway Union),*

by Mr. ASHTON DAVIES, O. B. E.,
Chief Commerciai Manager, London Midland and Scottish Railway Company.

## PART I.

## Introduction.

With a view to presenting a comprehensive review of the effects of the world crisis, and of road competition, on the railway position in recent years, fifty-three main-line railways not affiliated to the International Railway Union operating in different parts of the world, as well as the four British Railway Companies were approached for information.

I desire to express my indebtedness to the administrations named hereunder, for the valuable data they have kindly placed at my disposal :

| Railway Administration. | Country. |
|---|---|
| Buenos Aires & Pacific Railway. | *Argentine.* |
| Buenos Aires Great Southern Railway. | |
| Buenos Aires Western Railway. | |
| Central Argentine Railway. | |
| Ceylon Government Railway. | *Ceylon.* |
| State Railways. | *Egypt.* |

| | |
|---|---|
| Compagnie française des Chemins de fer de l'Indochine et du Yunnan. | *French Indo-China.* |
| Chemins de fer Coloniaux de l'Afrique Occidentale Française. | *French West Africa.* |
| Great Western Railway. | *Great Britain.* |
| London & North Eastern Railway. | |
| London Midland & Scottish Railway. | |
| Southern Railway. | |
| Burma Railway. | *India.* |
| Indian State Railways : | |
| (*a*) Eastern Bengal Railway. | |
| (*b*) Great Indian Peninsula Railway. | |
| (*c*) North Western Railway. | |
| South Indian Railway Company. | |
| Great Southern Railways. | *Ireland.* |
| Kenya & Uganda Railway. | *Kenya and Uganda.* |
| Port et Chemin de fer de Lourenço-Marquès. | *Mozambique.* |
| State Railways in the Netherlands Indies. | *Netherlands Indies.* |
| South African Railways and Harbours. | *Union of South Africa.* |
| Delaware & Hudson Railroad Corporation. | *United States of America.* |
| Reading Company. | |
| Central Railroad of New Jersey. | |

It will be seen that I have been able to review the circumstances prevailing in Great Britain and Ireland, in North and South America, in countries situated in the north, south, east and west of Africa, as well as in India and other countries in the southern part of Asia.

I venture to suggest that the collation of information from such widely separated and different quarters cannot fail to be of interest and, further, that the generalisations outlined in this report can be regarded as portraying the broad trend of events over a considerable part of the civilised world.

As a prelude to the consideration of the subject now before us, we might turn our thoughts to previous reports which I have had the honour to present upon the effects of the World Crisis and road competition on the railway position.

In concluding a report dated April 1934 (1), various important facts which had emerged in the review were outlined, of which the following are germane to the present discussion :

firstly, that in the case of each of the twelve countries brought within the scope of the review, the world crisis which began in 1929 had diminished railway revenues;

secondly, that in all these countries, the situation had been made worse by road competition, and the necessity for co-ordination of road and rail transport had been recognised by legislative authorities generally;

thirdly, that intensive efforts to effect economies had led to improved operating methods which might never have been introduced without the stimulus of financial stringency;

while

fourthly, as a means of counteracting road competition, railway administrations had introduced additional facilities for passenger and freight traffic, with, in some instances, concurrent modifications in rates and fares.

A little over a year later (report dated

(1) See *Bulletin of the Railway Congress*, June 1934, p. 525.

May 1935) (2), it was possible to indicate that in the countries which had previously been commented upon, the critical period of the depression appeared to have passed, and there were signs that in some countries recovery was slowly taking place. At the same time there was evidence that the danger of allowing unrestricted and uneconomic competition to exist against the railways was appreciated and definite progress was being made, by legislation, towards the co-ordination of transport resources and the elimination of wasteful competition.

My present report reviews the trend of rail traffics and development in road transport from 1929 to 1935, the action taken by legislative authorities in connection with road transport, and the changes in commercial policy adopted by railway administrations to meet the situation with which they have been confronted.

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## PART II.

# Trend of railway traffics (1929-1935).

Speaking in general terms the economic crisis began to spread throughout the world in 1929/30 and, taking railway receipts as a unit of measurement, the shrinkage in trade continued in a sharp decline until 1932-33 and, whilst an upward tendency has since developed in practically all countries, the rate of improvement has been less pronounced than that of the decline.

In Table I particulars are given of the gross revenues of the different railway administrations previously named. These have, however, been submitted in the different currencies of the countries concerned, and for the purpose of simplification, a further Table (No. II) has been prepared in which all figures have been related to 1929, those for that year being expressed as 100.

It will be seen from these tables that improvement occurred from 1934 to 1935 in the case of sixteen administrations, the increases varying from 0.9 to 13.9 per cent. On the other hand, nine administrations suffered a diminution of revenue, in three cases exceeding 5 per cent.

In only two cases, viz., Lourenço-Marquès and South African Railways, did the 1935 gross revenues exceed the 1929 figures.

In the absence of comprehensive information as to the industrial production in the different countries, and the effects of the fiscal policies of the Governments concerned upon internal and international trade, it is difficult to say whether the railways have participated to the full extent in the volume of traffic available for transport.

It would, however, appear that where increases have occurred in railway traffics, the improvement has been contingent to some extent on increased production and the consequential greater purchasing capacity of the population.

Other factors which in certain countries have contributed towards recovery in railway revenue include :

(*a*) Improved crops and/or their higher market value enabling growers to travel more and buy more goods which in turn are carried by rail;

(*b*) Measures taken by the various railway administrations to counteract the effects of the world crisis and to combat road competition;

(*c*) Legislation which has limited, or at least regulated, the activities of road competitors.

(2) See *Bulletin of the Railway Congress*, July 1935, p. 765.

TABLE I.

**Gross receipts of reporting Railway Administrations.**

(*000's omitted*).

| Railway administration. | Currency. | 1929 | 1933 (*) | 1934 | 1935 | Percentages Inc. (+) or Dec. (−) 1935 compared with 1934. |
|---|---|---|---|---|---|---|
| Buenos Aires & Pacific. . . | £ | 8 857 | 5 827 | 6 116 | 6 491 | + 6.1 |
| Buenos Aires Gt. Southern . | £ | 13 067 | 10 560 | 10 516 | 10 958 | + 4.2 |
| Buenos Aires Western . . . | £ | 5 275 | 3 546 | 3 612 | 3 513 | — 2.7 |
| Central Argentine. . . . . | £ | 13 610 | 9 749 | 10 386 | 10 020 | — 3.5 |
| Ceylon Government Ry. . . | Rupee | 32 499 | 19 712 | 20 980 | 18 273 | — 12.9 |
| Egyptian State Rys . . . . | £E | 7 039 | 4 707 | 5 046 | 5 120 | + 1.5 |
| Indo-China & Yunnan Rys. . | Piastre | 4 776 | ... | 3 766 | 3 946 | + 4.7 |
| French West Africa Colonial Rys . . . . . | Franc | 92 183 | ... | 65 773 | 59 561 | — 9.4 |
| Great Western . . . . . | £ | 36 184 | 28 424 | 29 280 | 29 789 | + 1.7 |
| London Midland & Scottish . | £ | 81 661 | 65 291 | 68 180 | 69 455 | + 1.8 |
| London & North Eastern . . | £ | 63 295 | 48 790 | 51 376 | 51 819 | + 0.9 |
| Southern. . . . . | £ | 26 507 | 22 598 | 23 153 | 23 517 | + 1.6 |
| Burma Ry . . . . . | Rupee | 49 779 | ... | 36 647 | 37 833 | + 3.2 |
| Eastern Bengal . . . . . | » | 72 986 | ... | 55 814 | 54 400 | — 2.5 |
| Gt. Indian Peninsula . . . | » | 159 193 | ... | 127 632 | 126 738 | — 0.7 |
| North Western . . . . . | » | 183 752 | ... | 152 633 | 158 383 | + 3.8 |
| South Indian . . . . . | » | 66 742 | ... | 53 713 | 55 136 | + 2.7 |
| Gt. Southern Rys. (Ireland) . | £ | 4 250 | 3 000 | 3 964 | 4 198 | + 5.9 |
| Kenya & Uganda Ry . . . | £ | 2 449 | 2 088 | 2 227 | 2 385 | + 7.1 |
| Lourenço-Marquès Ry . . . | £ | 573 | ... | 700 | 792 | + 13.1 |
| Netherlands Indies State Rys. | Florin | 82 739 | 34 019 | 30 256 | 28 682 | — 5.2 |
| South African Rys. & Harbours | £ | 27 583 | 20 620 | 24 997 | 28 463 | + 13.9 |
| Delaware & Hudson . . . . | Dollar | 46 461 | ... | 23 913 | 23 499 | — 1.7 |
| Reading Company . . . . | » | 97 197 | ... | 53 078 | 51 374 | — 3.2 |
| Central Railroad of New Jersey. | » | 58 137 | ... | 29 022 | 29 523 | + 1.7 |

(*) Extracted from previous report dated May 1935 (*Bulletin of the Railway Congress*, July 1935).

It may be said that, broadly, the increases would have been greater had road competition been less severe. This view is supported by the fact that in the countries where road operators' activities have been most strictly regulated the rail receipts have increased to the greatest extent. Examples are the South African Railways, the Kenya & Uganda and the Great Southern of Ireland, which show large percentage increases in gross receipts for 1935 compared with 1934.

Where the rail receipts have continued to decrease, this has almost invariably been due to the growth and intensification of road competition, supplemented in certain instances by other factors. For example, because of the low price

TABLE II.

**Changes in gross receipts — 1929 and 1933/5.**

| Railway administration. | Index 1929 = 100 | | | 1935 compared with 1933. | 1935 compared with 1934. |
|---|---|---|---|---|---|
| | 1933. | 1934. | 1935. | | |
| Buenos Aires & Pacific | 66 | 69 | 73 | + 7 | + 4 |
| Buenos Aires Great Southern | 81 | 80 | 84 | + 3 | + 4 |
| Buenos Aires Western | 67 | 68 | 67 | ... | — 1 |
| Central Argentine | 73 | 76 | 74 | + 1 | — 2 |
| Ceylon Government Ry | 61 | 65 | 56 | — 5 | — 9 |
| Egyptian State Rys | 67 | 72 | 73 | + 6 | + 1 |
| Indo-China & Yunnan Rys | ... | 79 | 83 | ... | + 4 |
| French West African Rys | ... | 71 | 65 | ... | — 6 |
| Great Western | 79 | 81 | 82 | + 3 | + 1 |
| London Midland & Scottish | 80 | 83 | 85 | + 5 | + 2 |
| London & North Eastern | 77 | 81 | 82 | + 5 | + 1 |
| Southern | 85 | 87 | 89 | + 4 | + 2 |
| Burma Ry | .. | 74 | 76 | ... | + 2 |
| Eastern Bengal | ... | 76 | 75 | ... | — 1 |
| Great Indian Peninsula | ... | 80 | 80 | ... | ... |
| North Western | ... | 84 | 87 | ... | + 3 |
| South Indian | ... | 80 | 83 | ... | + 3 |
| Great Southern Rys (Ireland) | 71 | 93 | 99 | + 22 | + 6 |
| Kenya & Uganda Ry | 85 | 91 | 97 | + 12 | + 6 |
| Lourenço-Marquès Ry | ... | 122 | 138 | ... | + 16 |
| Netherlands Indies State Rys | 41 | 37 | 35 | — 6 | — 2 |
| South African Rys & Harbours | 75 | 91 | 103 | + 28 | + 12 |
| Delaware & Hudson | ... | 51 | 50 | ... | — 1 |
| Reading Company | ... | 55 | 53 | ... | — 2 |
| Central Railroad of New Jersey | ... | 50 | 51 | ... | + 1 |

of jute, the Bengal Government introduced a Jute Restriction Scheme, which led to the jute crop of 1935 being only 25 % of the 1934 total.

Moreover, care is necessary in attempting to draw any conclusions as to volume of traffic from a comparison of receipts over a period of years, as in many cases railway rates and fares have been reduced appreciably in order to overcome diminished purchasing power or to combat road competition, and it may be that a substantial increase in traffic carried is represented by only a slight increase — or in extreme cases by an actual decrease — in revenue compared with earlier years.

Examination of the revenues of the various administrations reveals that generally where gross revenue has increased, the improvements have been in both passenger and goods traffic. For example, the sixteen administrations mentioned as having earned greater

gross revenue in 1935 than in 1934 can be classified as follows :

*Administrations showing increases in both passenger and merchandise receipts (10).*

Buenos Aires & Pacific.
Buenos Aires Great Southern.
Egyptian State Railways.
French Indo-China & Yunnan Rys.
Great Western (G. B.).
London Midland & Scottish (G. B.).
Burma Railway.
Great Southern Rys. (Ireland).
Lourenço-Marquès Railway.
South African Railways.

*Administrations showing increases in merchandise receipts only (4).*

North Western (India).
South Indian.
Kenya & Uganda Railway.
Central Railroad of New Jersey.

*Administrations showing increases in passenger receipts only (2).*

London & North Eastern (G. B.).
Southern (G. B.).

In my previous reports I was able to pay tribute to the manner in which rail-

TABLE III.

**Net railway receipts or deficiency (*).**

*(000's omitted).*

| Railway administration. | Currency. | 1929. | 1933 (*). | 1934. | 1935. |
|---|---|---|---|---|---|
| Buenos Aires & Pacific | £ | 2 434 | 993 | 1 456 | 1 774 |
| Buenos Aires Great Southern | £ | 4 312 | 3 143 | 3 169 | 3 386 |
| Buenos Aires Western | £ | 1 818 | 652 | 774 | 564 |
| Central Argentine | £ | 3 905 | 1 900 | 3 438 | 2 748 |
| Ceylon Government Ry | Rupee | 6 502 | 392 | 2 037 | — 638 |
| Egyptian State Rys | £ E. | 2 953 | 1 465 | 1 707 | 1 613 |
| Indo-China & Yunnan Rys | Piastre | 779 | ... | 488 | 771 |
| French West Africa — Colonial Rys. | Franc | 8 807 | ... | 17 583 | 12 378 |
| Great Western | £ | 7 440 | 4 453 | 4 969 | 4 971 |
| London Midland & Scottish | £ | 15 855 | 10 106 | 11 256 | 12 412 |
| London & North Eastern | £ | 12 400 | 7 293 | 7 855 | 7 874 |
| Southern | £ | 5 593 | 4 505 | 4 753 | 5 041 |
| Burma Railway | Rupee | 19 679 | ... | 8 549 | 9 321 |
| Eastern Bengal | » | 7 455 | ... | — 9 703 | —12 176 |
| Great Indian Peninsula | » | 54 616 | ... | 34 509 | 34 858 |
| North Western | » | 50 789 | ... | 28 776 | 32 066 |
| South Indian | » | 27 035 | ... | 22 499 | 23 024 |
| Great Southern Rys (Ireland) | £ | 928 | 322 | 507 | 546 |
| Kenya & Uganda Railway | £ | 1 004 | 1 098 | 1 233 | 1 297 |
| Lourenço-Marquès Railway | £ | 288 | ... | 376 | 475 |
| Netherlands Indies — State Rys | Florin | 25 271 | — 1 710 | — 849 | 75 |
| South African Rys & Harbours | £ | 5 805 | 7 448 | 6 762 | 8 716 |
| Delaware & Hudson | Dollar | 7 809 | ... | — 2 601 | — 2 775 |
| Reading Company | » | 21 268 | ... | 16 193 | 15 622 |
| Central Railroad of New Jersey | » | 15 919 | ... | 8 774 | 8 060 |

(*) Extracted from previous report dated May 1935 (*Bulletin of the Railway Congress*, July 1935).

ways all over the world had reacted to the double misfortune of road competition and world depression. They had displayed ingenuity in discovering new sources of economy on the operating side and in many instances, by widening their field of service, had improved their net revenue position.

Information which has since come into my possession demonstrates that there has been a continuance of this dual effort and the figures which I give in Tables III and IV show that in the case of no less than sixteen administrations the net revenue position in 1935 was better than in 1934. This position has been achieved by further reduction in expenditure or by keeping the increase in expenditure at a lower level than the increase in gross receipts.

TABLE IV.

**Changes in net railway receipts — 1929 and 1933/5.**

| Railway administration. | Index of net receipts 1929 = 100 | | | 1935 compared with 1933. | 1935 compared with 1934. |
|---|---|---|---|---|---|
| | 1933. | 1934. | 1935. | | |
| | | | | Points | Points |
| Buenos Aires & Pacific | 41 | 60 | 73 | + 32 | + 13 |
| Buenos Aires Great Southern | 73 | 73 | 79 | + 6 | + 6 |
| Buenos Aires Western | 36 | 43 | 31 | — 5 | — 12 |
| Central Argentine | 49 | 88 | 70 | + 21 | — 18 |
| Ceylon Government Ry | 6 | 31 | — 10 | — 16 | — 41 |
| Egyptian State Rys | 50 | 58 | 54 | + 4 | — 4 |
| Indo-China & Yunnan Rys | ... | 63 | 99 | ... | + 36 |
| French West Africa — Colonial Rys. | ... | 199 | 141 | ... | — 58 |
| Great Western | 60 | 67 | 67 | + 7 | + |
| London Midland & Scottish | 64 | 71 | 78 | + 14 | + 7 |
| London & North Eastern | 59 | 63 | 64 | + 5 | + 1 |
| Southern | 81 | 85 | 90 | + 9 | + 5 |
| Burma Railway | ... | 43 | 47 | ... | + 4 |
| Eastern Bengal | ... | — 130 | — 163 | ... | — 33 |
| Great Indian Peninsula | ... | 63 | 64 | ... | + 1 |
| North Western | ... | 57 | 63 | ... | + 6 |
| South Indian | ... | 83 | 95 | ... | + 12 |
| Great Southern Rys (Ireland) | 34 | 55 | 59 | + 25 | + 4 |
| Kenya & Uganda Railway | 109 | 123 | 129 | + 20 | + 6 |
| Lourenço-Marquès Railway | ... | 131 | 165 | ... | + 34 |
| Netherlands Indies — State Rys | — 7 | — 3 | ... | + 7 | + 3 |
| South African Rys & Harbours | 128 | 116 | 150 | + 22 | + 34 |
| Delaware & Hudson | ... | — 33 | — 36 | ... | — 3 |
| Reading Company | .. | 75 | 73 | ... | — 2 |
| Central Railroad of New Jersey | ... | 55 | 51 | ... | — 4 |

Before passing to the next phase of my report I feel constrained to suggest that my generalisations may not wholly apply to the vast railway interests in the United States of America, inasmuch as I have only been able to judge the situation on the basis of information submitted by three administrations operating in the Great Lakes and Central Eastern regions.

PART III.

# Developments in road transport (1929-1935).

In order to appreciate the reasons underlying the commercial policy adopted by the railway administrations within the last two years to meet the position with which they have been confronted, it is necessary to bear in mind the part played by competitive road transport during and since the crisis period.

The decreases in railway receipts as from 1929 were in no small measure attributable to the growth of road competition, and for this reason that feature calls for special examination.

Perhaps the best approach to this problem is to attempt to assess the extent of the growth in the number of motor vehicles in use and the summary given below (Table V) reveals the situation in thirteen countries over a number of years.

TABLE V.

**Motor vehicles (thousands) in use at :**

| | DECEMBER : | | | | |
|---|---|---|---|---|---|
| | 1925 | 1929 | 1931 | 1933 | 1935 |
| Argentine | 178 | 359 | 336 | 325 | 291 |
| Ceylon | 10 | 20 | 40 | 20 | 23 |
| Egypt | 15 | 26 | 29 | 28 | 25 |
| French Indo-China | 8 | 21 | 22 | 14 | (*) |
| French West Africa | 2 | 6 | 9 | 7 | 4 |
| India | 79 | 164 | 180 | 173 | 165 |
| Irish Free State | 34 | 44 | 50 | 51 | 53 |
| Kenya and Uganda | (*) | (*) | (*) | (*) | 13 |
| Mozambique | 0.5 | 1.5 | 4 | 3 | 4 |
| Netherlands Indies | 38 | 71 | 84 | 71 | 58 |
| Union of South Africa | 63 | 142 | 156 | 169 | 242 |
| United Kingdom | 911 | 1 458 | 1 585 | 1 708 | 2 068 |
| United States | 19 844 | 26 565 | 26 132 | 23 820 | 26 167 |
| World total | 24 349 | 34 932 | 35 516 | 33 351 | 37 229 |

(*) Figures not available.

These figures have been adapted from particulars published annually by the Society of Motor Manufacturers and Traders (of Great Britain) and afford a broad indication of the general trend of road transport throughout the world.

It is necessary to point out, however, that the figures tabulated above have no regard to the capacity of the vehicles, the use made of them, or the range over which they are operated, all of which have an important influence upon the

degree of competition sustained by the railways.

Both freight and passenger transport have been affected by this competition, but they are best considered under separate heads, although in some instances there is not a clear dividing line between the two types of transport. To simplify comment, therefore, the subject will be summarised under the two distinctive heads.

### (a) Road competition for passenger traffic.

This takes two main forms, viz., (*a*) public service vehicles engaged on regular or occasional service, and (*b*) private cars. The degree of competition from the two classes varies considerably between one country and another.

The growth of passenger transport by public service road vehicles had its origin, principally, in the search for a cheaper method of travel than was afforded by rail, dictated by the reduced purchasing power of the population, whilst convenience of service was another primary factor.

Prior to the crisis, road passenger-carrying was nascent in the majority of the newer or less developed countries, but where there were dense populations and good roads as in Great Britain and the United States, there was already quite a high degree of road competition. In most countries, however, the competitive nature of road transport has tended to increase in recent years.

In Great Britain the competition became so severe in the late twenties that, on the recommendations of a Special Commission appointed by the Government, a licensing system for public service passenger vehicles was introduced under the Road Traffic Act of 1930.

This resulted in an immediate decline in the number of omnibuses, but although the number has not risen since, the seating capacity of the vehicles has increased, and the competition from this source is probably no less than in 1930. It can, however, be asserted that this legislative action has regularised the competition of public service road vehicles with the railways in Great Britain and has stabilised road fares generally at a higher level than operated under uncontrolled competition.

In the United States of America the growth has not been so controlled, and through amalgamations, absorptions and agreements, large and complicated road organisations have been built up. The Reading Company reports that it is possible to make journeys of 1 000 miles on the bus lines of one company operating in its territory, and there are a number of transcontinental routes upon which through bookings over even longer distances are possible. Competition between the road companies operating over these routes has led to the quotation of low fares, and long-distance travel by road has increased appreciably.

The coaches in use in the United States are specially designed for comfortable travel, those used for night journeys being equipped with either sleeping berths or reclining seats.

In the Irish Free State, road passenger services have practically been confined to those developed by the Great Southern Railways, road and rail services having been scheduled in complete co-ordination with each other.

In South Africa, passenger road transport is confined chiefly to the more densely populated areas, such as Capetown and Johannesburg, its popularity being based upon flexibility rather than cheapness. The competition has been kept within limits by the Central Road Transportation Board and Local Boards, appointed under the Motor Carrier Transportation Act of 1930, which have encouraged the operation of road services working in conjunction with the railways in preference to services competitive with them.

In the remaining countries public road passenger carrying services were comparatively undeveloped until the crisis period, and were confined to the environs of the larger towns. Since then, however, the reduced circumstances of the travelling public, combined with the desire of vehicle owners to earn additional income has led to the running of intermittent services between principal towns at fares lower than those charged by the railways. In some cases the services have been made regular, and the fares fixed, but in others the service and the fares are dependent upon the demand.

In summarising the views expressed by the different railway administrations, it cannot be definitely stated that the competition of public service vehicles has yet reached its limits.

In those countries where regulatory measures have not been introduced, the range of competition has continued to increase, and the rivalry between road operators has tended to depress the level of fares.

In India, Ceylon, Mozambique and parts of the Netherlands Indies, diversions from rail continue, and in the Argentine, the replacement of earth tracks by constructed roads, under the ægis of the Government, is assisting competition against rail travel.

In other countries, a balance between road and rail would seem to be emerging, and the railway position has been improved by some passengers having reverted to rail as a result of various measures adopted by the railways to meet the force of road competition, coupled with legislative action. Generally speaking, the reversions have been in the lower classes of travellers.

In those countries where the comfort of the passenger is a primary consideration, as, for example, in Great Britain and Ireland, U. S. A., and South Africa, it has to be recognised that the competition between road operators has resulted in improved types of road passenger carrying vehicles being introduced during the last few years. Generally speaking, this amenity has not been accompanied by a higher fare level.

The competition of the private motor car is on a different footing from that of the public service vehicle, and has assumed considerable proportions in recent years.

Initial outlay and subsequent upkeep play a part in restricting the ownership of private cars, and to this extent any growth in numbers is largely dependent upon the prosperity of nationals. This is exemplified by the experience in the United States of America where the higher standard of living is reflected in the larger number of cars per 1 000 inhabitants.

The crisis, and its attendant lowering of the level of prosperity, exercised a deterrent effect on the purchase of new cars, and at the same time, led to others passing out of use, but in some countries, such as Ceylon, where control of public carrying is not widely exercised, car-owners embarked on the carriage of passengers to the detriment of the railways.

With the upward tendency in national prosperity which is now developing, it is to be feared that competition from the private car will be intensified.

One feature of the competition of the private motor car is that it has affected first-class travel by rail more adversely than lower classes.

Recently, however, the British Railways have shown increases in the number of first-class passengers carried, partly as the result of the reduced rates introduced on 1st January 1935 to encourage that class of travel, and partly due to increasing prosperity. In South Africa, Ireland and Indo-China, also, first-class rail travel has shared in the general increase in passenger traffic but in no case has first-class travel attained the pre-crisis volume.

### b) Road competition for freight traffic.

Road competition for freight traffic developed somewhat later than that for passenger traffic, and although by 1929 in such countries as Great Britain, U. S. A. and South Africa, it had become a formidable antagonist to rail interests, in others it was only in an embryonic state.

In all countries, however, the general reduction in the volume of traffic available, brought about by the world crisis, has intensified the competition, and railway administrations have been faced with more vigorous attacks from professional hauliers. At the same time there has been a tendency for traders owning suitable transport equipment to go beyond their normal sphere of business and seek to carry freight on behalf of others.

Hauliers have resorted to conveyance over longer distances, and have not only catered for a wider range of commodities, but have in some countries such as Great Britain, built up organisations for dealing with miscellaneous traffics moving in small quantities even down to a few pounds in weight.

A factor in the competition of considerable importance and advantage to road operators has been the improvement in design of road vehicles achieved by manufacturers, particularly in the shape of high-capacity vehicles, the substitution of diesel engines for petrol, and the reduction of tare weight in relation to carrying capacity.

Taking Great Britain as an illustration, the growth in the numbers of freight carrying vehicles as between 1929 and 1935 is to be seen in the subjoined Table VI.

TABLE VI.

**Petrol and oil-driven goods vehicles in use in Great Britain as at September 1929 and 1935.**

| Unladen weight. | 1929 | 1935 | Increase. | | Decrease. | |
|---|---|---|---|---|---|---|
| | | | No. | % | No. | % |
| Up to 1 ton . . . . . | 148 558 | 121 984 | ... | ... | 26 574 | 18 |
| 1 to 2 tons . . . . . | 06 | 181 285 | 85 479 | 89 | ... | ... |
| 2 » 3 » . . . . . | 20 079 | 74 226 | 54 147 | 270 | ... | ... |
| 3 » 4 » . . . . . | 24 896 | 17 935 | ... | ... | 6 961 | 28 |
| 4 » 5 » . . . . . | 22 532 | 15 162 | ... | ... | 7 370 | 33 |
| Over 5 » . . . . . | 4 133 | 7 778 | 3 645 | 88 | ... | ... |
| Total. . . | 316 004 | 418 370 | 102 366 | 32 | ... | ... |

*Note.* — The above table shews only vehicules with petrol or oil-driven engines. Electric and steam vehicles (which in 1929 represented 3 % and in 1935 less than 1 % of the aggregate) have been omitted.

It will be appreciated that these figures simply represent the numbers of vehicles registered under certain categories of unladen weights, and do not necessarily give an indication of carrying capacity.

I am advised by a competent authority that in Great Britain the carrying capacity of vehicles of given unladen weight has been increased since the first half of 1933 by at least 20 % on an average. This is equivalent to one extra vehicle

for every five registered so far as carrying capacity is concerned, and if the comparison were made with 1929 the difference would be even greater.

The principal cause of transference of freight from rail to road conveyance is the lower rate charged by road operators, and there is conclusive evidence that throughout all countries within the ambit of this review, the competition among hauliers brought about by the lesser demand for transport has forced down road rates and thereby rendered combative action on the part of railway administrations more difficult.

The improvements in vehicle design mentioned above have benefited hauliers in enabling them to make reductions in charges, and the practice of overloading even where such is a contravention of regulations, has aggravated the situation.

* * *

Another development inimical to railway interests which has spread throughout the principal towns and cities in Great Britain is the establishment of what are known as « road clearing houses ». These are really agencies which collect information as to loads available for transport, which they offer at very low rates to hauliers who would otherwise be undertaking an unladen journey.

Confronted with a problem which, throughout the period of the world crisis, was becoming more dangerous to their interests, railway administrations in general appear to have made strenuous efforts to compete with their opponents, and, as is shown later in this report, have modified their commercial practice in varying degree.

In some countries they have been assisted by legislative measures, promulgated by national Governments, in the shape of control or limitation by licensing provisions or by the imposition of taxes in various forms.

Information supplied by the different railway administrations leads to the conclusion that legislative action is playing, and must continue to play, an important part in resolving the position as between rail and road transport of both passenger and freight traffic, and it seems appropriate at this juncture to refer to steps taken in various countries in this respect.

## PART IV.

## Legislative measures affecting road transport, adopted since 1929.

The subject falls under two heads, viz., taxes imposed on vehicles and/or fuel used, and regulations directed towards the control of road transport operations.

### (a) Taxes imposed on vehicles and/or fuel.

These methods of taxation have as their objective the collection of revenue to cover, in some part, the cost of providing and maintaining roads and regulating traffic in the interests of the community and, in some cases, as a contribution to general administrative expenditure.

Divergent practices have been adopted in the countries in which the reporting administrations operate and in some, separate taxes are payable to Municipal, State or Provincial, and Federal authorities.

Individual provinces within the same country frequently have different tax levels or even charging methods, but, in

general, the taxes have one common function, viz., the levying of a charge in proportion to the use and wear and tear of the roads.

Briefly the taxes may be described in the following manner :

*Vehicle taxes.* — Generally speaking, these take the form of a fixed annual sum, the basis of which is determined by the type of vehicle or the purpose for which it is used. Passenger vehicles plying for hire are usually taxed according to seating capacity, and private cars and freight vehicles according to their unladen weight.

There are, however, many variations of these general bases. For example, in Great Britain private cars are taxed according to horse power, whereas in India, the wheel base (or wheel base × wheel track) is the criterion; taxes also differ according to whether or not pneumatic tyres are used; according to the roads upon which the vehicles operate (Indo-China), the range of operation (Egypt); or to the type of fuel used for propulsion (Netherlands Indies), while, in other cases, brake taxes (India) or registration fees, are levied.

In most cases vehicle duties are of but recent imposition, having taken the place of mere nominal registration fees, or of low charges on an arbitrary basis. In Great Britain, higher rates came into force from January 1st, 1934, the increases being imposed on the grounds that road operators were not paying their proper share of road costs, and new taxes were introduced in the countries named below in the years shown :

| | |
|---|---|
| Mozambique | 1933 |
| Indo-China | 1934 |
| Egypt | 1934 |
| South India | 1935 |
| Netherlands Indies | 1935 |

*Fuel taxes.* — Petrol is the principal fuel used for motor vehicle propulsion, and the tax is usually on volume (gallon or litre) but sometimes on weight. In Netherlands Indies, where petrol mixed with paraffin (which is taxed at a much lower rate) is used, vehicles equipped to use this mixture are taxed at a higher rate.

Only limited information is available in regard to revenue collected in the form of vehicle and fuel taxes, but where such detail has been forthcoming, vide Table VII, the figures show increases in 1935 compared with 1929.

TABLE VII.

**Revenue derived from vehicle and fuel taxes.**

| State or Country. | 1929 | 1935 |
|---|---|---|
| | *Dollars* | *Dollars* |
| State of Pennsylvania : | | |
| Vehicles | 29 160 690 | 32 065 654 |
| Petrol | 31 708 768 | 40 708 840 |
| | *Rupees* | *Rupees* |
| Ceylon | 1 076 783 | 1 214 683 |
| | £ | £ |
| Irish Free State | 772 703 | 985 885 |
| | *Florins* | *Florins* |
| Netherlands Indies : | | |
| Fuel | 18 070 000 | 19 356 000 |
| Vehicles | ... | 336 000 |
| | £ | £ |
| Great Britain | 26 301 965 | 30 480 176 |

### (b) Regulations directed towards the control of road transport operations.

Legislative action taken in various countries to regulate the operation of road vehicles (passenger and freight) has varied considerably both in nature and degree.

A number of different factors, often of a conflicting character, have helped to determine the degree of regulation as, for example, the need for affording some measure of protection to revenues of railways, particularly those which are State-owned or State-guaranteed, as opposed to the desire not to stifle a new means of transport which might facilitate development of the resources of the particular country concerned. The position in different countries, as indicated by reporting administrations, appears to be :

*South Africa.*

From its advent just after the war, competitive road transport in the Union increased to such a degree by 1928 that a Government Commission was appointed to investigate and report upon « the whole problem of road motor competition and its bearing upon the road motor and railway services of the South African Railways Administration ».

The Commission recommended that there should be reasonable control and regulation of public road transport without the institution of any form of monopoly, and this was implemented by the Motor Carrier Transportation Act, which became operative from 1st January, 1931.

The provisions of the Act are administered by a Central Transportation Board assisted by a local Transportation Board in each of the proclaimed transportation areas.

The primary function of these boards is to regulate the volume of motor transport operating within any proclaimed area or over any proclaimed route, due regard being paid to the requirements of traffic both passenger and freight and the extent to which adequate transport facilities are already provided by rail or road.

The original Act was designed to control and co-ordinate rail services with road motor transport operated for reward, but by an amendment in August 1932, the system of control was extended to manufacturers and traders to the extent that conveyance of their own goods was confined to magisterial districts within which their places of business are situated. In urban districts the radius includes two or more adjoining districts.

Certificates are issued to operators authorising the conveyance of traffic for reward over defined routes or within restricted areas, and holders of these certificates are required to render to the Boards schedules disclosing the number of passengers and/or weight (in lb.) of goods conveyed by them.

The operation of the Act and its amendments is said to have eliminated long-distance road transport, but during the year ended 31st March, 1935, road hauliers conveyed over the shorter distances 64 000 000 passengers and 725 000 tons of freight. These represent increases of 15 % and 31 % respectively over the previous year compared with increases of 10 % in passengers and 15 % in tonnage conveyed over all distances by railway.

*Great Britain.*

The growth of road competition after the War led to severe curtailment of railway revenues and following investigations of a Government Commission, legislation was introduced in the form of the Road Traffic Act, 1930.

In addition to regulating the working hours of drivers of all commercial motor vehicles, passenger and freight, this Act introduced a system of licensing of « public service » (passenger) vehicles. As already indicated, the adoption of licensing has regularised competition for passenger traffic and road fares have been

stabilised, in general, at higher levels than previously.

The competition of freight carrying vehicles, however, escaped any legislative control until a system of licensing was brought into force under the Road and Rail Traffic Act of 1933.

Under this Act no person may use a goods vehicle on a road for the carriage of freight except under one or other of three types of licences, namely :

« A ». — Public carriers' licences, permitting the holder to use the authorised vehicles anywhere for the carriage of goods for hire or reward or for the carriage of goods in connection with his business as a carrier of goods — renewable every two years.

« B ». — Limited carriers' licences, permitting the holder to use the authorised vehicles either for the carriage of his own goods or for the carriage of goods for others for hire or reward, the latter being subject to such limitations as to extent of operations or as to the classes of goods to be carried as may be imposed by the Licensing Authority. These licences are renewable annually.

« C ». — Private carriers' licences, permitting the holder to use the authorised vehicles *only* for the carriage of his own goods — renewable every three years.

There is no limitation of a licensee to any particular class of licence, and a person may hold two or more licences of similar or different types.

For administrative purposes the country was divided into ten areas, each under the jurisdiction of a competent licensing authority who may exercise his discretion in regard to the issue of « A » and « B » licences, but must grant « C » licences on demand, except where the character of the applicant is in question. There are, however, special provisions in respect of vehicles to be used exclusively, under contract, for the carriage of goods during any continuous period of not less than one year, when the contracting haulier is entitled to an « A » licence, subject to conditions for ensuring that the vehicles are used for no other purpose.

Subject to certain qualifications, objections to the granting or renewal of « A » and « B » licences may be lodged by persons who are already providing facilities for the carriage of goods for hire or reward in the district, or between the places which applicant intends to serve, on the ground that suitable transport facilities already existing are, or would be if the application were granted, in excess of requirements; or that any of the conditions of a licence held by applicant have not been complied with.

An aggrieved person may appeal against a decision of the Licensing Authority to the Appeal Tribunal constituted by the Road and Rail Traffic Act, 1933.

It is a condition of every licence issued under the 1933 Act that :

The authorised vehicle shall be maintained in a fit and serviceable condition :

Any statutory provisions in respect of restrictions as to speed and the loading of vehicles are complied with : The requirements in respect of driver's hours as set out in the Road Traffic Act of 1930 are observed :

The provisions relating to the keeping of records are complied with.

In the case of « B » licences, the Licensing Authority may, in addition, apply all or any of the following conditions :

That the vehicles shall only be used in a specified district or between specified places :

That certain classes of goods only shall be carried :

That goods shall be carried only for specified persons.

Such other conditions (not being conditions with respect to the rates to be charged) as the Licensing Authority may think fit to impose in the public interest and with a view to preventing uneconomic competition.

It should be noted that the Licensing Authorities have no jurisdiction over the quantum of rates charged by road hauliers.

Whilst the functioning of this licensing system has undoubtedly had some restrictive effect on the growth in the number of road vehicles employed for freight transport, the numbers licensed have continued steadily to increase, and the Railway Companies are now seeking to establish that there should be curtailment of vehicles operating by road on trunk routes where existing rail facilities are adequate for dealing with an increased volume of traffic and the services provided are suited to the commercial needs of the industrial community.

*Irish Free State.*

In the territory served by its railway, the Great Southern Railways Company has, except in Dublin City, practically a monopoly of the passenger carrying road service and competition is very limited.

Competition for freight, however, increased considerably until a licensing system was brought into operation by the Road Transport Act of 1933, which limited the aggregate unladen weight of vehicles licensed to the total unladen weight of vehicles in service during a specified period prior to the operation of the Act. A number of areas around the principal cities were exempted from the general provisions of the Act, and road operators were to be free to carry and to expand within these areas.

The Act also limited the number of hours and regulated the conditions of work and minimum wages of road motor drivers.

Under the Act the Great Southern Company was empowered to acquire by purchase the haulage business of any of its road competitors, and I am advised that, up to July 1936, the Company had acquired some 230 firms. The result has been that some traffic has been diverted either to rail or to the railway's road services.

*Indo-China.*

A decree promulgated in July 1933 enacted that no motor transport service (freight or passenger) should be operated without an authorisation by the Governor General or a local Administrative Head.

For regular services, the authority defines the number of vehicles, routes to be covered, stopping places, schedule of services, and the maximum tariffs, and drivers have to carry the latest receipt, bearing reference to the authorisation of the service.

In order to secure a rational co-ordination of inland transport and to limit the use of roads in the public interests, motor transport services, passenger and freight, are subject to tolls on routes served by both rail and road. For the purpose of taxing regular motor services, the roads are classified into three categories :

(1) Those not exceeding five kilometers from the railway and passing through at least two places situated within the range of different railway stations or halts.

(2) Those not exceeding ten kilometres from the railway and passing through at least two places situated within the range of different railway stations or halts.

(3) Those joining two places situated in the zones of different railway stations or halts but not passing within ten kilometres of the railway.

In addition to a differentiation in classes of road, the tolls levied also take into account the route mileage, frequency of service and carrying capacity of the vehicle.

On roads not included in the above categories, no toll is charged but drivers of vehicles must carry a copy of the order authorising the inception of the service.

Occasional transport is subject to a

daily charge varying according to the capacity of the vehicle.

*United States of America.*

From the earliest days of motor transport it was necessary for every person seeking to commence operation as a common carrier in Pennsylvania and certain other states to obtain the approval of the Public Service Commission or similar authority, but there was no Federal regulation of motor transport until the passing of the Motor Carrier Act of 1935. This Act provides that :

No common carrier by motor vehicle may engage in the carriage of passengers or freight between one State and another unless he has been granted a certificate of public convenience and interest issued by the Inter-State Commerce Commission.

The certificate shall specify the service to be rendered, and the routes over which the vehicle is authorised to operate.

A comprehensive regulation of the rates and fares is provided for in the case of common carriers, and a lesser degree of regulation for the charges of contract carriers.

Rates of common carriers are required to be just, reasonable, and non-discriminatory; they must be published and filed with the Commission and strictly observed. Such rates may be changed by the Commission if found to be unlawful.

Transportation brokers (i. e., any persons not being common or contract carriers, who sell or offer for sale or arrange for transportation) are required to obtain licences from the Commission to continue or commence such functions.

The new law provides that the Commission may establish reasonable requirements with respect to maximum hours of service of employees. Subject to certain provisions it is permissible to transfer any certificate or permit.

The Commission is authorised to require annual, periodical, or special reports from all motor carriers (including brokers) and to prescribe the form of all accounts, records and memoranda to be kept by motor carriers and the length of time such documents shall be preserved including those relative to the movements of traffic as well as all receipts and expenditure of money.

It is anticipated that the Act will gradually bring about a curtailment of the present surplus of road transport, but such result will not apparently be achieved for some time, because the Commission is required to issue certificates or permits if the carrier or his predecessor shew any bona fide operation as a common or contract carrier by motor vehicle prior to June 1st, 1935, over the route or routes or within the territory for which application is made and has so operated since that time.

*Kenya and Uganda.*

Legislation has already resulted in a complete abolition of road transport competition on roads parallel to main line railways over sections where the railway is vitally affected, and a committee has recently been appointed by the Government to consider the desirability of regulating and co-ordinating all forms of transport.

*Ceylon.*

Legislation restricting the number of omnibuses operating over each route came into force in 1935 in order to reduce danger and difficulties arising from increasing competition between rival omnibus services. When, in the opinion of the licensing authority, licences have been issued for sufficient omnibuses to meet requirements on a particular route, no further licences are granted for that route.

It is anticipated that additional legislation which is now contemplated will effect a further improvement in the regulation of road transport.

*India.*

In order to co-ordinate development

of road and rail services and to place competition on an equal footing, a Central Transport Advisory Council was formed and that body made certain recommendations, including restriction of the number of buses, to avoid wasteful competition.

Many provincial Indian governments have since amended their motor vehicle regulations, but the amendments have not altogether followed the recommendations of the Council.

Provincial boards of communication have also been created and no important scheme of road, rail, or inland waterway development may be sanctioned by any local government unless and until such scheme has been discussed and approved by the appropriate provincial board.

The right to run their own buses was conferred upon the railways by the Indian Railways Amendments Act of 1933.

*Netherlands Indies.*

Public road transport is regulated by an Act of 1933, which requires all services to be licensed. Licences may be refused on the grounds of « tariffs or other considerations affecting public interest ».

In practice these regulations have proved ineffective because the « public interest » clause is too vague, and there is a large proportion of public passenger transport by motor cars which is free to operate without licences.

A new decree is being brought into operation in 1937, which will require freight vehicles of over 2 000 kgr. laden weight and motor cars used for public transport to be licensed. Licences for additional vehicles will be refused in those cases where it is considered existing public transport is adequate.

*Other Countries.*

I am advised that in the Argentine a bill is before Congress aiming at some control of road transport but no details have been supplied of its purport.

No information has been furnished by railways in Egypt and in French West Africa as to the position in those countries, and Mozambique is apparently without any legislation for restricting the operation of motor transport services.

It will be seen that restrictions on road operators' activities such as have been described above are all of comparatively recent inception. In general it is yet too early to report definitely on their full effect, and it transpires that whilst penalties for non-compliance with the various regulations are usually enumerated in the appropriate Acts or Orders, measures adopted to ensure observance of the laws are frequently insufficient and, therefore, ineffective.

No action appears to have been taken with their respective Governments by any reporting administrations in connection with the Resolution passed at the Eighth Congress of the National Chamber of Commerce held in Paris 24th-29th June, 1935, that :

The statistics demanded in respect of road and rail transport should be confined to those which show how the conditions of working conform to the co-ordination measures adopted, and define in the interest of full economy the movement of traffic.

The compilation of the transport statistics must be made in a uniform manner in all countries on account of the increasing importance of international traffic and in order to enable comparisons to be made between the various countries.

Certain statistical information is, however, already demanded of road operators in a number of countries, though not to the extent of placing road and rail on an equality in this respect. Typical examples are given below :

In Great Britain operators of passenger road vehicles are required to render to the Minister of Transport every three

months statistical information in respect of number of vehicles (classified according to seating capacity), number of passengers carried, passenger receipts, as well as receipts from the conveyance of parcels, mails, luggage, etc., and vehicle miles. No attempt has, however, been made by the British Government to obtain from road freight hauliers similar statistics to those which have to be rendered by the Railway Companies, although freight vehicle drivers are obliged to keep, for inspection if required by the police or by examiners appointed under the Road and Rail Traffic Act 1933, records of times when they commence and cease work and of their intervals of rest; together with particulars of the journey, the greatest weight of goods carried by the vehicle at any one time, a description of the goods and the destination thereof.

Road operators in South Africa (except those in purely urban areas) must render to the Transportation Boards particulars as to the number of passengers and/or weight of goods carried by them.

In the territory served by the Great Indian Peninsula Railway, road operators have to furnish in respect of each commodity carried, details of the quantity, the places between which the traffic is carried (so as to estimate the loss to railway), and the rates and transport charges. In the case of road passenger services, information is demanded as to the number of passengers carried between each pair of stations, number of trips made by each bus, fares charged, and operating cost per passenger mile. No attempt has, however, been made to place road and rail on a uniform basis so far as statistical information is concerned.

Road operators in the Irish Free State are required under the Road Transport Act 1933 to furnish the Ministry of Industry and Commerce with information which includes :

Number of road vehicles operated.

Tonnage of merchandise and number of live-stock carried.

Consumption of motor spirit and oil.

Number of vehicles scrapped and renewed during the year.

Unladen weight of lorries and tractors.

Basis and brief particulars of method of calculation in the provision for renewals.

## PART V.

# Changes in commercial policy made by Railway Administrations.

Notwithstanding the gradually developing improvement in the economic situation throughout the world the railways could not, in face of the contemporary rise in road competition, have approached the present position of increasing receipts had it not been for the acumen displayed in adjusting their commercial policy and applying methods for counteracting, at any rate to some extent, the effects of the growing competition with which they have been faced.

It affords me much gratification, therefore, to place before you some indication of the more noteworthy policies which have helped to make the comprehensive services and facilities provided by the railways at the present time unparalleled by any other system of transport.

Railway administrations have been active in this respect in various phases

embracing improvement of existing services, introduction of new facilities and modification of rates and fares, whilst in a number of cases they have either established new departments or reorganised their personnel in order more adequately to cover their commercial interests. I will comment on this latter feature in the first place.

### (a) Changes in organisation adopted by railway administrations.

It is almost universally recognised that railway companies must maintain the closest possible contact with traders and potential passengers to ascertain and be in a position to meet as far as practicable all their transport requirements. To assist in achieving this objective a number of railway administrations have in recent years introduced changes in departmental organisations — chiefly in the direction of strengthening the commercial sections.

An outstanding example of this is the step taken by the London Midland & Scottish Railway of Great Britain.

Up to 1932 the commercial functions for freight and for passenger traffic were under separate control, the former being under a Chief Goods Manager, and the latter under a Chief General Superintendent who was also responsible for all traffic operations, passenger and freight.

Convinced that commercial considerations were becoming of paramount importance, the L. M. & S. Company in 1932 decided upon a re-organisation designed to strengthen and improve contact with the public and to provide for the pursuit of a vigorous commercial policy through one officer responsible entirely and only for commercial issues.

The titles of Chief Goods Manager and Chief General Superintendent were accordingly superseded by those of Chief Commercial Manager and Chief Operating Manager, which were accorded to the two principal officers appointed to control commercial and operating matters respectively.

Because of the special position of Scotland and the desirability of having an Official of considerable status to concentrate on problems peculiar to that country a Chief Officer for Scotland was also appointed.

Contemporaneously, a measure of change was also introduced in the responsibility of District Officers, and a re-distribution of territory was accompanied by a partial amalgamation of duties.

Formerly, there had been dual representation throughout the country, officers responsible for passenger matters covering territory in which other officers were responsible for freight matters.

It was considered that this division of function left some parts of the country insufficiently covered for the proper pursuit of an intensified commercial compaign and to remedy this the distribution of territory was remodelled under four different types of District Officers.

The new district organisation can be described briefly as under :

| | |
|---|---|
| In large cities, such as London, Manchester, Liverpool and Birmingham, and surrounding country (varying in radii). | District Passenger Managers responsible to Chief Commercial Manager for passenger commercial matters. |
| | District Goods Managers responsible to Chief Commercial Manager for freight commercial matters and to Chief Operating Manager for freight terminal operations and cartage. |

| | |
|---|---|
| In other parts of the country (except at L. M. S. Docks). | District Goods and Passenger Managers responsible to Chief Commercial Manager for freight and passenger commercial matters and to Chief Operating Manager for freight terminal operations and cartage. |
| L. M. S. Docks. | Dock Superintendents responsible to Chief Commercial Manager and Chief Operating Manager respectively for commercial and operating matters affecting Docks. |

More recently commercial matters associated with coal, previously the sole concern of a separate Mineral Manager, have been brought within the province of the Chief Commercial Manager, and in turn within the ambit of District Officers responsible for freight matters.

The L. M. S. Chief Commercial Manager is responsible for the sales effort and results accruing therefrom for all descriptions of transport. He is, therefore, in effect, the Company's Public Relations Officer in a wide conception of the term, and holds the responsibility for ascertaining the requirements of the public and of traders, and of meeting such ascertained requirements by the design and introduction, on the most modern lines, of every possible measure and facility whereby the demand for railway transport may be definitely stimulated.

The broad principle governing the question of satisfying public requirements is that the Chief Commercial Manager decides what is necessary to secure the business, and the other departments of the Company — Operating and Technical — co-operate with him in carrying the arrangements into effect.

The other British Railways have also considerably augmented their commercial activities during recent years, without introducing any fundamental changes in organisation.

I am able to indicate below other changes in organisation made by railway administrations in various parts of the world :

*Buenos Aires Great Southern* and *Buenos Aires Western.* — Commencing from 1st March, 1933, the operating and commercial branches of the Great Southern Railway were made into separate departments, and in July of the same year a similar division was made on the Western Railway.

The newly formed Traffic (or Commercial) Departments of the two Companies were then brought under one official without any amalgamation of personnel and the operating departments were likewise placed under single control. The object of this change was to leave the Traffic Superintendent free to attend to purely commercial work.

In order to effect economy of working and standardisation of practice the commercial branches of the Great Southern and Western Railways were in May 1935 fused into a single organisation.

*Buenos Aires & Pacific.* — Commercial matters have been segregated from general traffic working and specialised efforts made to combat road competition.

*Central Argentine.* — A special road transport section has been created to maintain contact with and report upon, all competitive road transport activities.

*Eastern Bengal.* — The commercial organisation has been strengthened by the opening of a Research Section with the objects of establishing closer relationship between the administration and trading public, exploring new avenues

of income, and keeping in touch with road officers of the local government, the Research Officer acting as a liaison officer between the railway and local governments.

*Great Indian Peninsula Railway.* — A special section has been formed to deal with motor competition by suggesting steps to retain goods and passenger traffic to rails and also to divert it from road to rail; the section also examines and reports upon all road development schemes and alterations to motor vehicle regulations likely to affect railway interests.

*Netherlands Indies Railway.* — Operating work has now been separated from purely commercial functions which are left in the hands of special commercial inspectors. The inspectors are stationed at the most important trade centres and their primary function is to seek both goods and passenger traffic.

*South Indian Railway.* — The Commercial Department is now responsible for fixing the timings and number of passenger trains run over the system. Previously this work was done by the Transit Department.

*Reading Company and Central Railroad Company of New Jersey.* — Whilst there have been no fundamental changes, expansion has been made in the organisation to combat road competition for freight, by assigning special representatives to devise means to meet the competition.

* * *

In seeking information as a basis for this report, questions were included as to practices adopted by railway administrations for canvassing or soliciting traffic, and whether any changes had been introduced in recent years.

It would appear that, in general, administrations have not found it necessary to modify their practices fundamentally, except in the case of the North Western Railway of India, where a special sales branch was inaugurated in June 1934, comprised of officers and staff specially selected and trained for the purpose.

I may perhaps be forgiven for mentioning also that, in connection with the organisation of the Commercial Department of my own Company, new canvassing posts have been created as a means of securing more extensive contact with the travelling and trading public, and the whole sales force has been completely overhauled. Further, greater attention is now given to the selection of individuals for this class of work and we are pursuing a policy of educating our canvassing staff in the technique of salesmanship.

It may also be of interest to refer to another innovation in our service, viz., the L. M. S. Quota Scheme. The Company's new commercial policy is based on the principle that the personal interest of every member of the staff should be enlisted to ensure that the services provided shall be of the highest possible standard of efficiency from the standpoint of public appeal and variety, and a means was required for creating voluntary competition within the organisation to maintain this principle.

As so often happens, when necessity calls, a solution emerges, and in our case the Quota scheme became a stimulating force in our sales effort.

The Quota scheme is applied to each section and type of traffic — passenger and parcels, merchandise and coal — and the quota represents the aggregate gross receipts in total, and under each head, assessed for each district, station and canvasser as their objective for the particular year. The sum in each case represents the previous year's receipts plussed or diminished by an appropriate

LMS STATION

# QUOTA

193

**GOODS TRAIN TRAFFIC**

**PASSENGER TRAIN TRAFFIC**

| | SUN. | | MON. | | TUES. | | WED. | | THUR. | | FRI. | | SAT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GOODS | PASS. | GOODS | PASS. | GOODS | PASS. | GOODS | PASS. | GOODS | PASS. | GOODS | PASS. | GOODS | PASS. |
| Day's Quota | | | | | | | | | | | | | | |
| ,, Actual | | | | | | | | | | | | | | |
| Cumulative Q. | | | | | | | | | | | | | | |
| ,, A. | | | | | | | | | | | | | | |
| Day's Quota | | | | | | | | | | | | | | |
| ,, Actual | | | | | | | | | | | | | | |
| Cumulative Q. | | | | | | | | | | | | | | |
| ,, A. | | | | | | | | | | | | | | |
| Day's Quota | | | | | | | | | | | | | | |
| ,, Actual | | | | | | | | | | | | | | |
| Cumulative Q. | | | | | | | | | | | | | | |
| ,, A. | | | | | | | | | | | | | | |
| Day's Quota | | | | | | | | | | | | | | |
| ,, Actual | | | | | | | | | | | | | | |
| Cumulative Q. | | | | | | | | | | | | | | |
| ,, A. | | | | | | | | | | | | | | |
| Day's Quota | | | | | | | | | | | | | | |
| ,, Actual | | | | | | | | | | | | | | |
| Cumulative Q. | | | | | | | | | | | | | | |
| ,, A. | | | | | | | | | | | | | | |

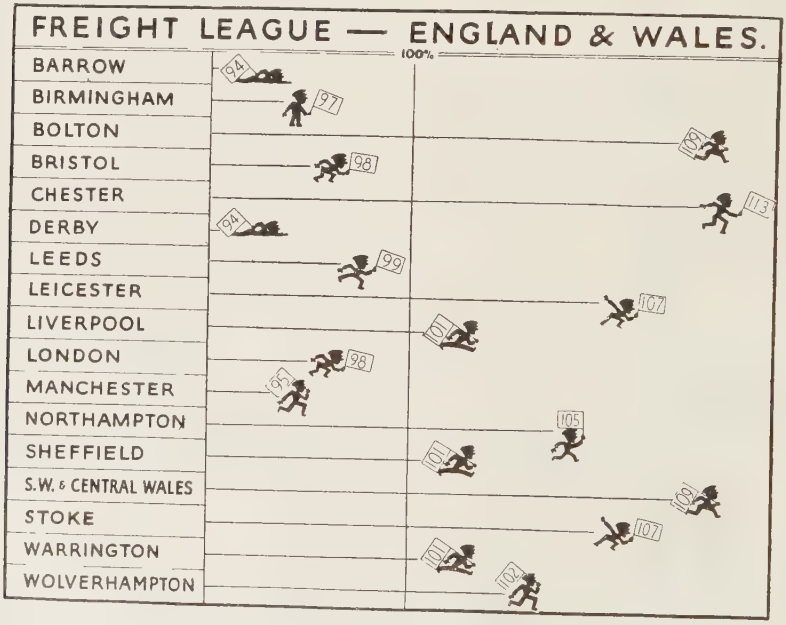
percentage according to how it is estimated local trade conditions may influence the demand for transport.

To encourage continuous striving to achieve the task laid down, calendars are provided on which a day to day record can be made of results, and in addition « district » and « station » league tables are utilised to illustrate the merit of each unit's effort in relation to its competitors. Apart from the circulation of information in respect of these tables through the normal organisation, a periodical, known as *Quota News*, is distributed monthly to all ranks in the Commercial Department, in which the League tables are reproduced together with chatty comments on commendable effort displayed in securing or dealing with traffic, and short articles on matters of commercial interest.

Challenge shields and cups are awarded annually to stations and districts showing the greatest improvement in receipts over the previous year's figures.

The Quota scheme has unquestionably assisted in inculcating in the widespread staff of the L. M. S. an earnest desire to compete with each other in the Company's interests and the degree of success achieved can be measured from the fact that taking the railway undertaking as a whole 97.24 % of the quota was reached in 1934, and 96.08 % in 1935.

By way of illustration reproductions are given of a page of the L. M. S. Quota calendar and below of the manner in which the League tables are displayed in *Quota News*.




(b) **Changes in commercial policy affecting passenger traffic.**

Before commenting on this subject I will give statistics relating to the numbers of passengers carried by, and the receipts accruing to, Administrations in 1934 and 1935 compared with 1929. These are recorded respectively in Tables VIII and IX.

TABLE VIII.

**Numbers of passengers carried by railway (1929-34-35).**

| Railway administration. | Passenger journeys (000's omitted) | | | | |
|---|---|---|---|---|---|
| | Year. | 1st Class. | 2nd Class. | Other than 1st & 2nd Class. | Total. |
| Buenos Aires & Pacific | 1929 | 6 285 | 12 034 | ... | 18 319 |
| | 1934 | 4 797 | 7 658 | ... | 12 455 |
| | 1935 | 4 638 | 7 125 | ... | 11 764 |
| Buenos Aires Gt. Southern | 1929 | 27 139 | 32 351 | ... | 59 490 |
| | 1934 | 22 904 | 30 163 | ... | 53 067 |
| | 1935 | 22 693 | 30 196 | ... | 52 889 |
| Buenos Aires Western | 1929 | 12 600 | 10 958 | ... | 23 558 |
| | 1934 | 11 589 | 9 303 | ... | 20 892 |
| | 1935 | 11 376 | 9 421 | ... | 20 797 |
| Central Argentine | 1929 | 24 230 | 26 077 | ... | 50 307 |
| | 1934 | 18 547 | 23 712 | ... | 42 259 |
| | 1935 | 18 471 | 24 690 | ... | 43 161 |
| Ceylon Government Ry | 1929 | 145 | 740 | 18 527 | 19 412 |
| | 1934 | 64 | 337 | 11 075 | 11 476 |
| | 1935 | 54 | 298 | 9 865 | 10 217 |
| Egyptian State Rys. | 1929 | 800 | 2 383 | 23 667 | 26 850 |
| | 1934 | 611 | 2 362 | 31 583 | 34 556 |
| | 1935 | 586 | 2 482 | 33 784 | 36 852 |
| French West Africa | 1929 | 22 | 37 | 1 078 | 1 137 |
| | 1934 | 6 | 10 | 921 | 937 |
| | 1935 | 5 | 10 | 1 286 | 1 301 |
| Great Western (G.B.) | 1929 | 1 159 | ... | 113 362 | 114 521 |
| | 1934 | 797 | ... | 95 218 | 96 015 |
| | 1935 | 917 | ... | 97 036 | 97 953 |
| London Midland & Scottish (G.B.) | 1929 | 4 714 | 6 | 294 423 | 299 143 |
| | 1934 | 3 180 | 4 | 283 110 | 286 294 |
| | 1935 | 3 500 | 4 | 293 216 | 296 720 |
| London & North Eastern (G.B.) | 1929 | 3 155 | 1 516 | 195 420 | 200 091 |
| | 1934 | 2 123 | 1 184 | 176 878 | 180 185 |
| | 1935 | 2 364 | 1 151 | 183 215 | 186 730 |
| Southern (G.B.) | 1929 | 4 652 | 572 | 194 946 | 200 190 |
| | 1934 | 3 441 | 375 | 209 375 | 213 191 |
| | 1935 | 3 973 | 383 | 214 495 | 218 851 |
| Burma | 1929 | 70 | 673 | 34 631 | 35 374 |
| | 1934 | 27 | 242 | 20 061 | 20 330 |
| | 1935 | 24 | 255 | 20 457 | 20 736 |
| Eastern Bengal | 1929 | 124 | 519 | 51 154 | 51 797 |
| | 1934 | 54 | 229 | 36 296 | 36 579 |
| | 1935 | 52 | 257 | 39 059 | 39 368 |
| Great Indian Peninsula | 1929 | 141 | 1 903 | 59 703 | 61 747 |
| | 1934 | 76 | 903 | 49 145 | 50 124 |
| | 1935 | 72 | 876 | 49 103 | 50 051 |

TABLE VIII. (*cont'd*).

| Railway administration. | Passenger journeys (000's omitted) | | | | |
|---|---|---|---|---|---|
| | Year. | 1st Class. | 2nd Class. | Other than 1st & 2nd Class. | Total. |
| North Western of India . . | 1929 | 138 | 805 | 88 405 | 89 348 |
| | 1934 | 57 | 356 | 60 511 | 60 924 |
| | 1935 | 52 | 331 | 65 503 | 65 886 |
| Great Southern (Ireland) . . | 1929 | 952 | 238 | 12 832 | 14 022 |
| | 1934 | 691 | ... | 11 816 | 12 507 |
| | 1935 | 816 | ... | 13 888 | 14 704 |
| Kenya & Uganda. . . . . | 1929 | 20 | 60 | 1 082 | 1 162 |
| | 1934 | 8 | 27 | 450 | 484 |
| | 1935 | 7 | 28 | 446 | 481 |
| Lourenço - Marquès (Mozambique) . . . . . | 1929 | 13 | 58 | 210 | 281 |
| | 1934 | 7 | 57 | 195 | 259 |
| | 1935 | 7 | 59 | 204 | 270 |
| Netherlands Indies . . . . | 1929 | 285 | 6 738 | 54 442 | 61 465 |
| | 1934 | 102 | 3 500 | 28 493 | 32 095 |
| | 1935 | 94 | 3 321 | 27 246 | 30 661 |
| South African Rys . . . . | 1929 | 28 865 | 23 583 | 29 546 | 81 994 |
| | 1934 | 25 516 | 22 702 | 27 539 | 75 757 |
| | 1935 | 27 174 | 23 746 | 32 361 | 83 281 |
| Reading Company . . . . | 1929 | One class only | | | 16 341 |
| | 1934 | do. | | | 8 905 |
| | 1935 | do. | | | 9 617 |
| Central Railroad of New Jersey . . . . . | 1929 | do. | | | 29 022 |
| | 1934 | do. | | | 16 348 |
| | 1935 | do. | | | 16 273 |

TABLE IX.

**Railway receipts from passenger traffic (1929-34-35).**

| Railway administration. | Currency | Year | Passenger receipts (000's omitted). | | | |
|---|---|---|---|---|---|---|
| | | | 1st class | 2nd class | Other than 1st and 2nd class. | Total. |
| Buenos Aires and Pacific . . . | £ | 1929 | 739 | 625 | ... | 1 364 |
| | | 1934 | 412 | 348 | ... | 760 |
| | | 1935 | 411 | 353 | ... | 764 |
| Buenos Aires Great Southern . . | £ | 1929 | 1 890 | 1 254 | ... | 3 144 |
| | | 1934 | 1 507 | 1 142 | ... | 1 649 |
| | | 1935 | 1 501 | 1 152 | ... | 1 653 |
| Buenos Aires Western . . . . | £ | 1929 | 674 | 491 | ... | 1 165 |
| | | 1934 | 416 | 320 | ... | 736 |
| | | 1935 | 431 | 339 | ... | 770 |
| Central Argentine. . . . . | £ | 1929 | 1 886 | 1 467 | ... | 3 353 |
| | | 1934 | 1 195 | 1 068 | ... | 2 263 |
| | | 1935 | 1 181 | 1 110 | ... | 2 291 |

TABLE IX. (*Cont'd.*)

| Railway administration | Currency | Year | Passenger receipts (000's omitted) | | | |
|---|---|---|---|---|---|---|
| | | | 1st class | 2nd class | Other than 1st and 2nd class. | Total. |
| Ceylon Government Railway | Rupee. | 1929 | 606 | 1 567 | 8 487 | 10 660 |
| | | 1934 | 321 | 1 047 | 4 932 | 6 300 |
| | | 1935 | 295 | 918 | 4 062 | 5 275 |
| Egyptian State Railways. | £E | 1929 | 366 | 521 | 1 636 | 2 523 |
| | | 1934 | 212 | 343 | 1 196 | 1 751 |
| | | 1935 | 214 | 342 | 1 228 | 1 784 |
| French Indo-China and Yunnan Railway | Piastre. | 1929 | 41 | 61 | 1 371 | 1 473 |
| | | 1934 | 24 | 29 | 665 | 718 |
| | | 1935 | 32 | 29 | 725 | 786 |
| French West Africa | Franc. | 1929 | 2 630 | 1 268 | 15 455 | 19 353 |
| | | 1934 | 1 608 | 787 | 7 298 | 9 693 |
| | | 1935 | 1 562 | 786 | 8 692 | 11 040 |
| Great Western | £ | 1929 | 634 | ... | 8 146 | 8 780 |
| | | 1934 | 421 | ... | 6 586 | 7 007 |
| | | 1935 | 462 | ... | 6 758 | 7 220 |
| London Midland and Scottish | £ | 1929 | 1 682 | ... | 17 183 | 18 865 |
| | | 1934 | 1 098 | ... | 14 788 | 15 886 |
| | | 1935 | 1 163 | ... | 15 219 | 16 382 |
| London and North Eastern | £ | 1929 | 999 | 135 | 10 929 | 12 063 |
| | | 1934 | 710 | 94 | 9 244 | 10 048 |
| | | 1935 | 760 | 87 | 9 538 | 10 385 |
| Southern | £ | 1929 | 1 507 | 415 | 9 785 | 11 707 |
| | | 1934 | 774 | 278 | 9 028 | 10 080 |
| | | 1935 | 821 | 281 | 9 312 | 10 414 |
| Burma | Rupee. | 1929 | 480 | 968 | 13 832 | 15 280 |
| | | 1934 | 286 | 497 | 7 876 | 8 659 |
| | | 1935 | 283 | 460 | 8 099 | 8 842 |
| Eastern Bengal | Rupee. | 1929 | 690 | 1 010 | 24 693 | 26 393 |
| | | 1934 | 428 | 734 | 16 769 | 17 931 |
| | | 1935 | 440 | 774 | 17 140 | 18 354 |
| Great Indian Peninsula | Rupee. | 1929 | 2 332 | 2 824 | 35 340 | 40 496 |
| | | 1934 | 1 604 | 2 157 | 29 193 | 32 954 |
| | | 1935 | 1 594 | 2 199 | 27 884 | 31 677 |
| North Western | Rupee. | 1929 | 1 722 | 3 010 | 57 763 | 62 495 |
| | | 1934 | 1 112 | 2 084 | 44 246 | 47 442 |
| | | 1935 | 1 093 | 1 996 | 41 355 | 44 644 |
| South Indian | Rupee. | 1929 | 660 | 1 564 | 27 928 | 30 152 |
| | | 1934 | 363 | 1 152 | 23 100 | 24 615 |
| | | 1935 | 379 | 1 091 | 22 928 | 24 398 |
| Great Southern (Ireland) | £ | 1929 | 96 | 31 | 944 | 1 071 |
| | | 1934 | 65 | ... | 755 | 820 |
| | | 1935 | 67 | ... | 779 | 846 |
| Kenya and Uganda | £ | 1929 | 62 | 77 | 154 | 293 |
| | | 1934 | 30 | 54 | 78 | 162 |
| | | 1935 | 27 | 54 | 78 | 159 |
| Lourenço Marquès | £ | 1929 | 6 | 13 | 46 | 65 |
| | | 1934 | 3 | 10 | 32 | 45 |
| | | 1935 | 3 | 11 | 33 | 47 |

| Railway administration. | Currency | Year. | Passenger receipts (000' omitted) | | | |
|---|---|---|---|---|---|---|
| | | | 1st class. | 2nd class | Other than 1st and 2nd class. | Total. |
| Netherlands Indies | Florin | 1929 | 918 | 3 938 | 16 637 | 21 493 |
| | | 1934 | 336 | 1 126 | 7 194 | 8 656 |
| | | 1935 | 312 | 1 069 | 6 549 | 7 924 |
| South African Railways. | £ | 1929 | 1 930 | 1 947 | 1 670 | 5 547 |
| | | 1934 | 1 270 | 1 696 | 1 566 | 4 532 |
| | | 1935 | 1 299 | 1 829 | 1 779 | 4 907 |
| Delaware and Hudson | Dollar | 1929 | One class only. | | | 3 287 |
| | | 1934 | do. | | | 1 136 |
| | | 1935 | do. | | | 1 057 |
| Reading Company. | Dollar | 1929 | do. | | | 7 081 |
| | | 1934 | do. | | | 2 957 |
| | | 1935 | do. | | | 3 077 |
| Central Railroad of New Jersey | Dollar | 1929 | do. | | | 9 169 |
| | | 1934 | do. | | | 4 466 |
| | | 1935 | do. | | | 4 322 |

To simplify consideration of these features from a common standpoint, a further comparison is made in Table X wherein the « total » numbers of passengers carried, and receipts, have been calculated on the basis of 1929 figures equalling 100 in each case.

TABLE X.

**Comparison of numbers of passengers carried and rail receipts, 1934 and 1935 with 1929.**

| Railway administration. | Index of total passenger journeys 1929 = 100 | | | Index of total passenger receipts 1929 = 100 | | |
|---|---|---|---|---|---|---|
| | 1934 | 1935 | ... | 1934 | 1935 | ... |
| Buenos Aires and Pacific | 68 | 64 | — | 56 | 56 | + |
| Buenos Aires Great Southern | 89 | 89 | — | 52 | 52 | + |
| Buenos Aires Western | 89 | 88 | — | 63 | 66 | + |
| Central Argentine. | 84 | 86 | + | 67 | 68 | + |
| Ceylon Government Railway | 59 | 53 | — | 59 | 49 | — |
| Egyptian State Railway | 129 | 137 | + | 69 | 71 | + |
| French Indo-China and Yunnan Railways | ... | ... | | 49 | 53 | + |
| French West Africa | 82 | 114 | + | 50 | 57 | + |
| Great Western | 82 | 84 | + | 80 | 82 | + |
| London Midland and Scottish | 96 | 99 | + | 84 | 87 | + |
| London and North Eastern | 90 | 93 | + | 83 | 86 | + |
| Southern. | 106 | 109 | + | 86 | 89 | + |
| Burma | 57 | 59 | + | 57 | 58 | + |
| Eastern Bengal. | 71 | 76 | + | 68 | 70 | + |
| Great Indian Peninsula | 81 | 81 | — | 81 | 78 | — |
| North Western. | 68 | 74 | + | 76 | 71 | — |
| South Indian | ... | ... | | 82 | 81 | — |

TABLE X (*Cont'd.*)

| Railway administration. | Index of total passenger journeys 1929 = 100 | | | Index of total passenger receipts 1929 = 100 | | |
|---|---|---|---|---|---|---|
| | 1934 | 1935 | ... | 1934 | 1935 | ... |
| Great Southern (Ireland) | 89 | 105 | + | 77 | 79 | + |
| Kenya and Uganda | 42 | 41 | — | 55 | 54 | — |
| Lourenço-Marquès | 92 | 96 | + | 69 | 72 | + |
| Netherlands Indies | 52 | 50 | — | 40 | 37 | — |
| South African Railways | 92 | 102 | + | 82 | 88 | + |
| Delaware and Hudson | ... | ... | | 35 | 32 | — |
| Reading Company | 54 | 59 | + | 42 | 43 | + |
| Central Railroad of New Jersey | 56 | 56 | — | 49 | 47 | — |

+ = *Increase 1935 over 1934.* — = *Decrease 1935 below 1934.*

Viewed from this broad generalization, the figures in Table X shew :

*Comparing 1935 with 1929.*

Five administrations, viz.,

Egyptian State Railways.
French West African Railways.
Southern Railway (G. B.).
Great Southern Railways (Ireland).
South African Railways.

carried more passengers in 1935 than in 1929.

Passenger receipts for all administrations were below 1929, ranging from 32 to 89 % of the former year's totals.

In the following cases the 1935 passenger receipts were less than half of those of 1929 :

Ceylon Government Railway.
Netherlands Indies Railways.
Delaware & Hudson (U. S. A.).
Reading Company.
Central Railroad of New Jersey.

*Comparing 1935 with 1934.*

Of the 22 administrations rendering particulars of passenger journeys 14 shewed increases and 8 decreases; so far as the passenger receipts are concerned, information is available in respect of 25 administrations, 17 of which shew increases and 8 decreases.

Before passing from these statistical comparisons attention should be directed to a feature disclosed in Table VIII, viz., the much larger numbers of first-class passengers carried by the three Buenos Aires and the Central Argentine railways, in relation to total passengers, than is the case with other administrations. The figures of the South African Railways are also of interest from the point of view of the even distribution of passengers over different classes.

The following railways recorded increases in first class receipts and in the number of first-class passengers carried in 1935 compared with 1934 :

Great Southern Railways (Ireland).
South African Railways.
Great Western Railway (G. B.).
London Midland & Scottish Railway (G.B.).
London & North Eastern Railway (G. B.).
Southern Railway (G. B.).

*Passenger fares.*

It would appear that all reporting railway administrations have made modifications in their passenger fares and introduced new travel facilities as part of their policy to overcome the effects of trade depression and road competition.

Such measures cannot in all cases be entirely attributed to the conditions of the 1929-35 period, as even before that time some railway administrations were offering a wide range of cheap and attractive forms of travel, and it is difficult to determine whether additional traffic secured by a particular facility represents new business or diversions from road. It can, however, be claimed that the variety of concessions has resulted in increased passenger travel.

In only one instance, viz., the Delaware & Hudson has a general reduction been applied to single and return fares, although the Eastern Bengal and British Railways have adopted a reduced level of return fares covering travel in both directions.

In the majority of cases modifications have taken the form of different types of tickets issued at low fares with availability over either a limited mileage or for limited periods, and in their general nature, the facilities are very similar throughout the railway administrations. I have, therefore, deemed it more appropriate to confine myself to an outline of the main types of excursion or « occasional » tickets issued at reduced fares as applicable to the railways in general, with special mention only of those pronounced in character and peculiar to particular administrations.

The most common form of cheap ticket is the one issued for comparatively short journeys in thickly populated areas for shopping or recreation purposes. Such tickets are usually available for return on the day of issue only and sometimes the outward journey may not be commenced until after the early morning peak traffic has terminated.

« Day » and « week-end » tickets to seaside resorts, tourist centres, or places of interest, and tickets issued on the occasion of special events such as fairs, fetes, and exhibitions, are also common.

It is also customary to offer cheap travelling facilities for holiday travel, permitting the return journey to be completed within periods varying from one week to six months, and in some cases (e. g., Great Britain) break of journey is allowed at intermediate points on either the outward or the return journey.

Specially reduced fares are available for parties, e.g., school children, sports teams, and members of educational societies and similar associations.

Tickets are also issued (but only to a very limited extent) to cover combinations of rail, road, water and air travel; whilst some tickets embrace hotel accommodation, admission to theatres, etc.

Certain types of tickets are available only by certain trains, others on certain days, but many cheap return tickets are available by any train at any time, and this difference in availability is generally reflected in the basis of fare charged.

As examples of the more unusual type of ticket the following may be cited :

*Buenos Aires Great Southern.*

Round trip tickets enabling passengers to spend part of their holiday at seaside resorts and part in the hills.

*Buenos Aires Western.*

On holidays and occasions of national importance, tickets are issued for special excursions to the Federal Capital; first class accommodation is provided at second class single fare for the return journey.

*Egyptian State Railways.*

« Surprise train » tickets for travel by special train to an unadvertised and surprise destination. The fare is a fixed one of 160 m/ms. whatever the destination.

*British Railways.*

Weekly season tickets issued in holiday areas allowing unlimited travel over a specified area for seven days.

« Bulk travel » vouchers (available to firms whose carriage charges on merchandise by passenger or freight trains of any one Railway Company amounts to not less than £ 300 per annum), for use of the firm's employees when travelling on business. These vouchers represent a saving of 25 % on the third class standard fare.

*Eastern Bengal.*

« Travel as you like » tickets issued at Christmas and Easter for a fixed sum and permitting unrestricted travel for fifteen days.

*French West Africa.*

To facilitate migration of agricultural labourers to the most fertile regions, or to regions where there is a shortage of labour, special return tickets, valid for seven to eleven months are issued for the lowest class of travel. Fares vary, but the reduction is never less than 50 %.

The only instance of an increase in the level of fares is that of the Great Indian Peninsula Railway which reports that increases have been made in the first and second-class fares for distances over 150 miles and in third-class fares for passengers travelling by mail and express trains. On the other hand, however, third class fares by ordinary trains for distances over 50 miles have been reduced, and « zone » tickets have been introduced for third class passengers permitting unrestricted travel over certain sections of the railway for prescribed periods.

Closely associated with the question of fares is that of the number of classes of travel which railway companies provide.

The fact that passenger road transport vehicles almost universally cater individually for one class and, further, that light rail units are also usually confined to one class, prompts the question whether railway administrations might and could discontinue their present practice of providing accommodation for more than one class of traveller.

It cannot be found, however, that there has been as yet any prevailing tendency towards « one class only » on main-line trains; in fact, even where there is nominally only one class of travel as on the Reading Company and the Central Railroad of Philadelphia, Pullman cars are run (on which a supplementary charge is made) so that, in effect, there are two separate classes.

In certain parts of the world, circumstances definitely preclude any attempt to introduce such a policy. For example, the clientele of the French West African Railways consists not only of natives of different standards but also of Europeans, both civilian and military, and some segregation into classes is essential. The number of classes has, however, been reduced from four to three by fusing the third and fourth classes, which were in any case used almost exclusively by natives. The South African Railways & Harbours have also found it possible to run one-class trains for natives in certain suburban areas and reservations.

Conversely, on the Netherlands Indies Railways it has been found necessary to introduce a fourth class to combat cheap fares offered by road competitors and to counter the effect of the reduced wealth of the population resulting from the economic crisis.

It would appear that in general the scope for further reduction in the number of classes is very limited.

Careful consideration has been given to particulars furnished by reporting administrations in respect of the average receipt per passenger journey, but no useful conclusions can be drawn owing to the number of conflicting factors which bear on the issue.

**Improvements in time schedules.**

Acceleration of passenger train services has proved an important weapon in the railways' armoury against road competition and during the past three or four years much has been accomplished in this respect. On the majority of railways faster schedules are being run on main routes and the more important branch lines as well as on suburban services.

Not only has the journey time between more important centres been reduced, but in many instances the acceleration has enabled a more frequent service of trains to be run where increased frequency has been considered potentially profitable.

Speaking generally, the faster and augmented schedules have been made available to the public without any addition to the fare, but in one or two instances where special high-speed trains are run an extra charge is made. For example, a small supplement is charged on the « Silver Jubilee » streamlined train of the London & North Eastern Railway (Great Britain). With an overall speed of 67.1 m. p. h. this train has considerably curtailed the journey time between London and Newcastle, a distance of 268 miles. The Egyptian State Railways also run high-speed trains between Cairo and Alexandria, on which an extra charge is made.

In no case has it been found necessary or desirable to resort to a policy of deceleration of train services, although one or two isolated cases have occurred where unimportant trains are run at slower speed for the sake of economy. Sometimes mixed trains are run where the amount of traffic is insufficient to justify separate freight trains.

In a number of cases passenger trains have been withdrawn from branch and local lines where the services had proved definitely unprofitable and where it seemed unlikely that improved facilities would make them remunerative. Such lines have, however, generally been kept open for freight trains, although on the Great Southern Railways of Ireland operating expenses proved to be so heavy that it became more economical to close certain branches altogether and convey passenger and freight trafic by road transport services operated by the Railway Company.

The situation in French West Africa presents a special problem, because of very keen road competition for the custom of the native population which prefers convenience and frequency of service to high speed. The policy of the French West African Railway is dictated mainly by these considerations, although some regard has to be paid to fast schedules which are demanded by European passengers. To satisfy the requirements of the latter, light trains at accelerated speeds have been put into service between important centres and on branch lines serving densely populated areas, while to meet the natives' desire for convenience and frequency, vehicles of the lowest class are attached to regular goods trains, and liberal allowances made for conveyance of luggage and small inoffensive animals. This policy has given excellent results and considerable business has been regained from road transport.

Acceleration and increased frequency has been made possible in the case of the Southern Railway of Great Britain by the expansion of electrified railway operation.

The first portion of the Southern Railway was converted for electric traction in 1909, but the mileage has been increased year by year until, in 1936, 436 route miles have been electrified, including suburban lines and the main lines between London and the coastal towns of Brighton, Eastbourne and Hastings.

The permanent way has been improved where necessary and the colour light system of signalling adopted on the busiest portions of the line in order to shorten the sections and permit the running of more trains. The rolling stock consists of multiple units, which obviate shunting movements at terminals, ensuring a quick turn-round, and afford an easy method of reducing loads during slack periods of the day.

Electrified railway operation has also been in force for many years to a smaller degree in certain territories of the London and North Eastern and London Midland and Scottish Companies, notably in North London, the Tyneside district and Lancashire, and further conversion schemes are in progress in various parts of the country.

Whilst some administrations have found light rail units valuable as a means of effecting economies, of maintaining existing services as an alternative to retrenchment, and of expanding rail services where necessary to counter road competition, others do not regard them as altogether satisfactory, and in view of the conflicting opinions, I have thought it well to confine my comments to the following observations which are fairly representative of different points of view :

*French West African Railway.* — Light trains drawn by small engines (Weidnecht series 16 000) have been made up for branch lines and sections of main line. By reducing traction costs, these units have enabled skeleton passenger services to be maintained during periods when traffic is light so that little or no inconvenience is caused to regular native clients. The railway has, in addition, prepared the organisation of a fast service by the use of Micheline and other railcars, which will probably be put into service early in 1937. The Michelines or special railcars will be used on long-distance runs (Dakar to Bamako — 1 230 miles) and the other designs on shorter runs.

*South African Railways and Harbours.* — The running of light rail units has resulted in the saving of train mileage and in speedier services and, in certain cases, greater frequency has been made possible whilst the drift to road has been arrested.

*French Indo-China & Yunnan Railways.* — Five railcars have been put into service, three being run with second and third class, and two with third, fourth and intermediate class accommodation, and results appear to have been satisfactory.

*North Western Railway (India).* — Small power units have been tried, but the final policy will be determined by the results of experiments now being undertaken to ascertain the most economical type of unit to meet the requirements of the travelling public.

*British Railways.* — Use of light rail units in Great Britain has been mainly experimental and sufficient experience has not yet been gained to venture any final opinion on their success. They have, however, been found advantageous for filling gaps in normal services with a cheaper working unit and as a means of combating road competition. Experiments are in progress with inter-city services.

*Great Southern (Ireland).* — Use of light rail units cannot be developed owing to mixed nature of traffic which necessitates the provision of mixed trains on less important branch lines. A prolonged trial is being given to the use of a train of two units worked by electric self-contained batteries, but it is too early yet to give a full report on the results.

*Eastern Bengal Railway.* — Trials made with two Sentinel tractors (one broad gauge and one metre gauge) and a Clayton coach on the metre gauge, indicate that such units are not suited to the particular conditions prevailing.

Except in the Irish Free State, Mozambique and United States of America, railway administrations do not appear to have introduced railway-operated passenger road services, either to supplement or act as feeders to rail services.

In the Irish Free State, the Great Southern Railways Company operates practically all the road passenger services within its area, and schedules are, as far as practicable, co-ordinated with the running of trains, efforts being made to give connections wherever it is possible to do so. Where road services have been utilised in substitution for passenger trains withdrawn from branch lines, the time tables are specifically designed to secure connections with main line trains.

The Lourenço-Marquès Railway Co.'s road service mileage already exceeds its rail mileage, whilst the Reading Co.(Pa.) run their own motor coaches in lieu of trains withdrawn from branch lines.

**Improvements in railway passenger vehicles.**

Much has been done all over the world in recent years to improve the standard of comfort of passenger rolling stock, not only on long-distance expresses but also on suburban and branch line trains and this has without doubt been one of the important factors which have assisted the railways in combating road competition.

In only isolated cases have circumstances been such that improvements were considered unnecessary or impracticable owing to financial stringency.

In the case of express passenger services the amenities of travel have been steadily and progressively improved generally, notably in :

Design and upholstery of all classes of passenger stock.

Introduction of new types of sleeping car — including those for second and third class passengers — in many of which air conditioning has been installed.

Provision of bathrooms on some long-distance trains, as adjuncts to sleeping cars.

Improvement of lavatory accommodation and provision of towels and soap.

Extension of restaurant car facilities, including buffet cars.

Use of rubber flooring to minimise noise.

### (c) Changes in commercial policy affecting freight traffic.

Particulars of receipts from freight traffic of reporting administrations for the years 1929, 1934 and 1935 are given in Table XI hereunder, together with a comparison of the 1934 and 1935 figures against those of 1929 on a percentage basis.

TABLE XI.

**Railway freight receipts (1929-34-35).**

| Railway administration. | Currency. | Freight receipts. (000's) | | | Index of receipts 1929 = 100 | |
|---|---|---|---|---|---|---|
| | | 1929 | 1934 | 1935 | 1934 | 1935 |
| Buenos Aires Pacific | £ | 6 690 | 4 714 | 5 074 | 70 | 76 + |
| Buenos Aires Great Southern | £ | 6 800 | 5 328 | 5 672 | 78 | 83 + |
| Buenos Aires Western | £ | 2 604 | 1 709 | 1 582 | 66 | 61 — |
| Central Argentine | £ | 9 530 | 6 805 | 6 964 | 72 | 73 + |
| Ceylon Government Ry | Rupee. | 17 161 | 10 827 | 10 080 | 63 | 59 — |
| Egyptian State Rys | £ E | 3 930 | 2 694 | 2 748 | 69 | 70 + |
| French Indo-China and Yunnan Rys. | Piastre. | 2 946 | 2 845 | 2 976 | 97 | 101 + |
| French West Africa Colonial Rys. | Franc. | 65 621 | 47 399 | 43 657 | 72 | 67 — |
| Great Western | £ | 17 977 | 14 500 | 14 794 | 81 | 82 + |
| London Midland and Scottish | £ | 43 816 | 35 236 | 35 918 | 80 | 82 + |
| London and North Eastern | £ | 35 985 | 28 377 | 28 318 | 79 | 79 — |
| Southern | £ | 5 743 | 4 968 | 4 783 | 87 | 83 — |
| Burma | Rupee. | 27 654 | 22 565 | 24 081 | 82 | 87 + |
| Eastern Bengal | " | 39 835 | 32 760 | 30 834 | 82 | 77 — |
| Great Indian Peninsula | " | 98 644 | 77 783 | 78 239 | 79 | 79 + |
| North Western | " | 84 660 | 78 591 | 83 897 | 93 | 99 + |
| South Indian | " | 28 345 | 23 738 | 25 192 | 84 | 89 + |
| Great Southern Rys. (Ireland) | £ | 1 585 | 1 198 | 1 238 | 76 | 78 + |
| Kenya and Uganda | £ | 2 016 | 1 961 | 2 123 | 97 | 105 + |
| Lourenço Marquès Ry | £ | 456 | 624 | 710 | 137 | 156 + |
| Netherlands Indies State Rys | Florin. | 56 085 | 19 174 | 17 687 | 34 | 32 — |
| South African Rys | £ | 18 980 | 17 712 | 20 561 | 93 | 108 + |
| Delaware and Hudson | Dollar. | 35 212 | 20 848 | 20 770 | 59 | 59 — |
| Reading Company | " | 82 723 | 47 444 | 45 685 | 57 | 55 — |
| Central Railroad of New Jersey | " | 45 043 | 22 621 | 23 225 | 50 | 52 + |

+ = increase 1935 over 1934
— = decrease 1935 below 1934

Comparison on the « index » basis brings out the following features :

*Comparing 1935 with 1929.*

Four administrations, viz.,

Lourenço-Marquès Railway.
French Indo-China & Yunnan Rys.
Kenya & Uganda Railway.
South African Railways.

recorded receipts in 1935 in excess of 1929. (Incidentally it might be mentioned the first named was the only reporting administration to have achieved that position in 1934.)

Only one administration (Netherlands Indies, with 32 %) had less than 50 % of its 1929 receipts, and 16 railways obtained 75 % or over.

*Comparing 1935 with 1934.*

Out of 25 administrations 16 recorded increases and 9 decreases, in freight receipts.

**Freight tariffs, classification and conditions of carriage.**

The question of price determines very largely the traders' choice between rail and road transport, and it is indisputable that the growth of road competition has largely been encouraged by the apparent cheapness of this alternative to rail conveyance.

Generally speaking, the effect of road competition for freight has been most pronounced on the higher-graded traffics and the situation has been met in many cases by a reduction in rail tariffs, although methods adopted have varied on account of differences in rate structure and the degree of legislative control of the administrations.

Allied to, and frequently inseparable from, the action to combat road competition, are reductions in tariffs to assist staple industries affected by the world depression.

In the main, there has been an avoidance of an all-round reduction in freight tariffs, modifications usually being confined to certain traffics and the extent of reduction graded according to the intensity of the competition. Sometimes the desired result has been obtained by the lowering of particular and individual rates; in other instances, the classification of the commodity has been amended.

« Flat » rates or « agreed charges » have been adopted by some administrations (e. g., in Great Britain) to cover rail conveyance of the whole or part of a particular firm's traffic, the rate being based on the level of the previous charges by rail or by rail and road. This method has been applied to merchandise by passenger and freight trains and the charge has been based on either a weight or a « per package » basis according to a trader's particular requirement, whilst in one instance, a world-famed store, the agreed charge has been calculated on a fixed percentage of the traders' annual purchases.

In general, it can be said that the adoption of these special charges, which are subject to annual review and essential adjustment in renewal periods, has not only retained traffic to rail but has secured traffic previously conveyed by other forms of transport and has also benefited the railway companies and traders through simplified accountancy.

For parcels of small weight and bulk, many railways are faced with competition not only from road hauliers but from the postal authorities, and in Great Britain a reduction in the rates for parcels made by the Post Office in 1935 had to be met by a corresponding reduction in the railway companies' scale of charges for parcels up to 18 lb. in weight forwarded by passenger train. Whilst this step was necessary to conserve parcels to rail, its immediate effect was to reduce the railways parcels receipts very considerably.

Probably the South African Railways & Harbours shew the nearest approach to a basic reduction in freight charges. Although the effects of the world crisis had to be met partly by the introduction of surcharges, on certain rates, the policy has been towards reductions, and whenever possible the general level has been lowered so that the tariff relationship of different classes of traffics could be maintained. In a recent revision the level of tariffs 1 to 6 for all distances up to 200 miles was reduced.

In contrast, the North Western Railway of India leans towards an increase in the level of freight charges, and attempts are being made to increase the classification of certain commodities which it is considered can bear enhancement.

In some cases, also, railway administrations, in their efforts to combat road competition have modified some of the general terms and conditions under which merchandise is carried, and to retain traffic and the goodwill of their customers, have accepted liability for damage, loss, etc., beyond their legal responsibility. This practice has been adopted to a limited degree in Great Britain, and on the Buenos Aires and Pacific and the Central Argentine Railways.

There has, moreover, been some relaxation of packing requirements in respect of goods of a damageable nature to meet the tendency for traders to use lighter and cheaper types of receptacles; usually the railways have accepted the situation where the new packing has afforded reasonable protection to the goods. The Central Argentine Company reports that in consequence of costs entailed, packing has deteriorated not only in the case of damageable goods but for practically all classes of general merchandise.

Another means of attracting traffic to rail adopted by individual administrations is the provision of packing material. This course has been followed by the Buenos Aires Great Southern and Western Companies who supply, free of charge, special crates for the carriage of demijohns containing liquids. This has been done to satisfy shippers and to reduce the number of claims.

As an experimental measure, cane basket containers have been supplied free by the North Western (of India) Railway for loading fresh fruit forwarded from distributing centres by rail. The demand has increased and the experiment is being continued in a more intensive form.

The Reading Company of Philadelphia provide a facility having a similar effect — they have amended certain tariffs so that no charge is made for the weight of grain doors, blocking and staking, etc., provided by the shippers for protection and safe carriage of freight.

### Improvements in freight services and facilities.

Measures adopted by the Railway Companies to improve their freight services have taken various forms according to the extent and nature of the competition, the degree of pre-crisis railway development and the characteristics of the traffics requiring transport.

Generally speaking, the improvements have followed defined lines with the object of removing the disadvantages and adding to the advantages of rail conveyance.

Competitive road services, especially for full vehicle loads, have undoubtedly provided quicker transportation in many cases than is customarily available by rail, and to some degree Railway Companies have been faced with alleged later collection or acceptance of freight forwarded by road, as well as earlier delivery.

Improvements in rail transit have, therefore, been affected by :

Later acceptance of goods;
More prompt delivery;
Acceleration of train services, and
Substitution of short distance conveyance by road or by passenger train to and from connectional points.

Later acceptance of traffic has been undertaken by most of the reporting administrations but the experience of the Great Southern Railways Co. of Ireland is of particular interest in this connection.

Late acceptance of traffic was found to result in the late departure of freight trains and over-hours for the staff, not only of the railways, but also of carters and senders, and delay in starting trains reacted on deliveries next morning to such an extent that it was decided that

goods depots in the cities must be closed by 6.0 p. m. daily.

On the other hand, in Great Britain, where the Railway Companies cart the greater part of their freight to and from the terminals, there has been a tendency to countenance later collection or acceptance of traffic so long as the prompt despatch of freight trains has not been endangered.

The British Companies have also effected a material degree of acceleration of freight train schedules, especially through the greater utilization of vehicles fitted with vacuum brakes which permit of freight services being run at passenger train speeds.

Another process adopted by various administrations for quickening transits, especially in the case of small consignments requiring transhipment en route, is the use of road services, or passenger trains, as between concentration points and surrounding townships and villages.

On certain branch lines of the Egyptian State Railways, freight trains were not operated daily nor were the goods depots open for the acceptance of traffic each day of the week. This has, however, now been altered and depots are open for traffic every day, and on those occasions when freight services are not run, traffic is conveyed by passenger train to the nearest junction to make freight trains connections to destination.

As an additional facility to the trading community a scheme of « registered » transits has been introduced on the British Railways. The scheme is two-fold, comprising the « Green Arrow » service for freight train traffic, and « Blue Arrow » service for merchandise by passenger train. In each case, in addition to the normal charges, a registration fee is levied whether the traffic is a small package or a train load, and special labels bearing a green or blue arrow are provided for distinguishing the consignment, the invoice, and the wagon in which loaded. Special attention is devoted to these consignments so that delay at any point may be prevented, and although the facility has only been in existence about three years it has been adopted so extensively by traders that thousands of consignments are dealt with under the scheme each day.

Apart from improving point to point transits, railway administrations generally appear to have recognised that developments in competitive transport in the last decade call for a response in the form of a variety of facilities incidental to transport in its broadest sense.

For example, the majority of railway administrations, some of whom did not previously cart traffic to and from their terminals, have endeavoured to neutralise the advantage inherent in road conveyance from door to door by providing cartage facilities themselves.

In the United States « trucking » services have not generally been performed by the main line railways. The introduction of the facility of picking up and delivering merchandise has been proposed in the Eastern States but tariffs filed with the Interstate Commerce Commission to take effect from May 1936 were suspended. It was, however, anticipated when reporting that they would come into force before the end of 1936.

The development of collection and delivery services has perhaps reached a more advanced stage on British Railways than elsewhere, and some comment in regard to the variety of facilities now provided for door to door transport may be of interest.

By their own units or by Cartage Agents, British Railways have, for many years, afforded cartage for freight traffic to and from rail depots in all towns of any size, and in recent years this facility has been extended to smaller towns and rural areas, largely through what are known as « country lorry services ». These services, devised to provide for delivery of traffic from wayside stations to remote farms and villages, generally

in isolated cases the radius extends to function within a radius of 10 miles, but 20 miles. The services are available for any freight and the rates charged are graded according to weight of consignment and distance of cartage.

Another service of a more specialised character is that of railhead distribution. Provided at selected provincial cities, this facility is used for shop goods such as confectionery, tobacco and groceries, carried in bulk by rail to the railhead centre, and delivery is effected in small quantities to shopkeepers along defined lines of route extending in some cases as far as 25 miles. Whilst this facility is available for any trader, it is usually not undertaken until the scope of the service required and the rate to be charged have been agreed between Railway Company and trader.

The use of containers also appears to have been developed to a greater extent in Great Britain than in other countries covered by this review; in fact, whilst most administrations indicate that container conveyance has reached little more than the experimental stage, there has been continuous expansion on British Railways since the facility was introduced in 1926.

In the last six years (1930-35) the number of containers in use by British Railways has increased from 4 335 to 11 268.

Additional container equipment is a regular feature of stock construction programmes and whilst standardisation is in progress, new types are from time to time being introduced for traffics calling for special consideration. The following are examples of types designed to cater for particular traffics :

| *Type of container :* | *Used for :* |
|---|---|
| Insulated . . . | Chilled and frozen meat, fish, fruit and other perishable traffic. Many of these containers are provided with hooks for hanging sides of meat; some are fitted with bunkers for use of « dry ice » (solid ($CO_2$). |
| Ventilated . . | Fresh meat. Some can be converted to fully insulated containers and have roof bunkers for water ice. |
| Bicycle . . . . | Bicycles, unpacked. These containers are fitted with racks enabling up to 76 unpacked machines to be conveyed in two tiers. |
| Furniture . . | New furniture and household removals. The containers are fitted with slats to enable furniture to be secured against movement in transit. |
| « Dry ice » . . | Solid carbon dioxide (dry ice) in bulk. These containers are highly insulated and are loaded and unloaded through roof doors. |
| Hopper . . . | Grain and similar traffic in bulk for discharge through hopper bottom. |

Emerging from the use of containers the British Railways' furniture removal service has so developed during the last few years that the Companies can to-day claim to be the largest removal organisation in the country. Working in conjunction with reputable removal contractors, the British Railways make « all-in » quotations which cover not only the conveyance charges, but all incidentals of removal, such as packing china, hanging pictures, erecting beds, etc., and where desired by the client, furniture is held under load in containers for short periods.

I am advised that there has been no

development of this facility on the other reporting administrations, but the Egyptian State Railways state they now have the necessary container equipment available.

It is of interest to record that « cash on delivery » schemes have been adopted by the following administrations :

Buenos Aires & Pacific.
Buenos Aires Great Southern.
Buenos Aires Western.
Central Argentine.
French West African Railways.
Great Western Railway (G. B.).
London & North Eastern Ry. (G. B.).
London, Midland & Scottish Ry. (G. B.).
Lourenço-Marquès Ry.
Netherlands Indies State Rys.
Southern Railway (G. B.).

**New and improved rolling stock.**

Improvements in rolling stock and adoption of new types have been features of the policy of Railway Administrations in all parts of the world in recent years. Improvements have, in the main, been in the way of use of oil axle boxes, continuous braking, automatic coupling gears and steel construction.

It is of interest to note that the growth of road transport has led to several developments in the provision of stock by railway administrations. For instance, certain railways have supplied tanks for bulk conveyance of petrol, a recent example being the Central Argentine Railway, whilst to cater for the conveyance of motor cars, the Reading Company of Philadelphia now provides box cars specially fitted for the purpose, and the London Midland & Scottish and Great Western Companies of Great Britain have constructed motor car vans which can also be utilised for express parcels traffic and general merchandise respectively.

Developments are also emerging from the tendency , noticeable in certain trades, to despatch commodities in bulk. In Great Britain tank wagons are usually provided by traders and the large and growing volume of liquids passing in road tanks to consignees not having rail connection has led the British Railways to encourage the use of tank containers or road-rail tanks. This development is at present only in its infancy, but there are already signs that traffic will be secured to rail through this means.

The bulking of traffics has not been confined to liquids, however, and in the U. S. A. both the Reading Company and the Delaware & Hudson have introduced tank cars for the conveyance of cement in bulk. Grain hoppers have long been provided in that country and have recently been brought into use in Great Britain and in the Irish Free State.

Another important development which has become quite widespread is the provision of a refrigerated service. In the United States where long hauls are common, vehicles specially equipped for the conveyance of perishable traffics have long been provided either by the railway companies or the distributing companies, but elsewhere, refrigerated rail conveyance has been of more recent growth.

In Great Britain, the equable climate and short rail hauls characteristic of the country, restrict the need for refrigerated transport, and traffic arriving at the ports in a refrigerated state can generally be maintained in good condition by the use of insulated and refrigerator vans (precooled in some cases). The British Railway Companies have, however, recognised the importance of refrigerated transport being given from « door to door » and to meet this requirement, insulated containers of various types have been introduced and used extensively for home-produced and imported perishable commodities, including frozen and chilled

meat, frozen and cured fish, fresh soft fruits, cream, prepared foodstuffs, etc.

Greater interest in these facilities and the satisfactory development of several new streams of traffic have unquestionably been encouraged by experiments initiated and pursued by the British Railway Companies in the use of refrigerants (water ice and dry ice — solidified carbon dioxide).

In the Argentine, too, some progress has been made in this direction by the Buenos Aires and Pacific, the Great Southern and the Western Railways, each of them having provided new and improved types of vehicles including insulated tanks for pre-cooled milk in bulk, special ventilated wagons and refrigerator vans for fresh fruit, etc. Insulated wagons specially designed for meat, fruit and fish traffic have also been provided by the Central Argentine Railway.

The Railway Administration of French West Africa now possess insulated wagons and refrigerated containers for the conveyance of fresh meat and other perishable commodities, and in Egypt, special vans for perishable traffic have been introduced, refrigeration being afforded by means of either dry ice or water ice.

### (d) **Publicity.**

As part of their commercial practice, most railway administrations utilize various methods to advertise their facilities, particularly in respect of passenger travel, and I gather that the policy adopted during the 1929-35 period has varied considerably.

Simply expressed, the problem has been whether the need for economy outweighed the necessity for giving adequate publicity to the improved services which the railways had on offer, and judged by the course adopted the administrations may be divided roughly into two categories, viz. :

| Companies which have *reduced* expenditure on advertising. | Companies which have *intensified* their advertising. |
|---|---|
| Buenos Aires & Pacific. | Central Argentine. |
| Reading Company. | Ceylon Government Railways. |
| | Netherlands Indies. |
| Central Railroad of New Jersey. | Indo-China & Yunnan. |
| | British Railways. |
| Eastern Bengal. | North Western of India. |
| Great Indian Peninsula. | Great Southern Railways (Ireland). |
| Kenya & Uganda. | South African Railways & Harbours. |

By way of illustration it might be stated that the Reading Company's expenditure on advertising in 1935 was only one-fifth of that in 1923 and the Central Railroad of New Jersey have reduced theirs by more than 50 % since 1929.

Joint advertising by two or more Companies does not appear to have been widely adopted, chiefly no doubt because in most countries the territorial interests of individual railways are more or less isolated. On the other hand, however, the situation in Great Britain probably lends itself to joint advertising better than in other countries, and in recent years the four main line companies have embarked on extensive joint advertising schemes in respect of both passenger and freight transport.

Most railway administrations appear to make extensive use of their stations for poster display but it would seem that in the period of world crisis increasing use has been made in some cases of press publicity and dissemination of handbills, guides, etc.

In those countries where advertising by radio is permitted, railway administrations have also availed themselves of that facility.

### (e) Inter-railway co-ordination.

The need for economy and the existence of a common enemy in the shape of road competition practically put an end to the internecine competition of railways, which has in many cases been replaced by some form of co-operation or co-operative working.

In Great Britain co-operative working between railways has become a prominent feature in recent years by the institution of « pools » for competitive railway receipts. Three such pools have been formed :

| | |
|---|---|
| L. M. S. and L. N. E. . . . . | from 1st July, 1932. |
| L. M. S. and G. W. . . . . | from 1st January, 1933. |
| L. M. S., L. N. E. and G. W. . . | from 1st January, 1933. |

Under each of these schemes the competitive freight and passenger receipts of the pool companies are contributed to a common pool fund after deduction of an agreed amount to cover working and terminal costs. The funds are then shared between the respective pooling companies in ratio to their contributions during a « standard year » based on a pre-pool period.

There is also a pool between all British Railways in respect of parcels traffic carried by passenger train.

The objects of pooling are the elimination of wasteful competition and the simplification of operating and of accountancy, and its introduction in Great Britain has enabled the following advantages and economies to be reaped :

Closer working between the companies in protecting their mutual interests against outside competition.

Concentration of traffic at one station with reduction in handling staff and costs, cartage and engine power.

Co-ordination of working and staff supervision at contiguous stations.

Unified cartage control with better disposition of equipment; elimination of duplicate calls by cartage teams at traders' premises.

Joint use of stations and town offices.

Elimination of redundant competitive train services, both passenger and freight.

Better spacing in timing of passenger trains between important centres to afford more comprehensive rail service.

Adjustment of routings : the adoption of the best transit route resulting in quicker transits and better loadings.

Release of station equipment for use elsewhere.

Co-operation has also afforded other opportunities to obviate overlapping in providing for necessities of domestic interest to the Companies and, at the same time, has provided the travelling and trading public with improved and more extensive transport facilities.

I have dealt at some length with pooling in Great Britain but it can be assumed that where circumstances are propitious, co-ordination between railways has been effected on somewhat similar lines in other countries.

In the U. S. A. the Reading Company and the Pennsylvania Railroad entered into an arrangement whereby competing lines controlled by the two Companies in Southern New Jersey were operated as a unified system as from 25th June, 1933. These Administrations also permit tickets issued between certain stations to be used on the alternative routes of the two companies, and have also co-ordinated their engine facilities at Lebanon (Penn.).

The Reading Company and the Central Railroad of New Jersey have come to an arrangement whereby several offices and departments of the two railways have been consolidated and perform the work for both Companies.

The Central Railroad is now handling, through its Jersey City Terminal, certain freight traffic on behalf of the Baltimore and Ohio Railroad Company, and the Delaware and Hudson Railroad reports that at junction points, facilities have been consolidated and station agents made to cover dual functions, while improvements in freight train schedules have been effected by co-ordination.

In the Argentine, pooling between railways is effected to a limited extent in respect of traffic emanating from sections of different railways liable to intercompetition. Actual amalgamation or fusion can only be effected with Congressional Authority and representations are being made to the Government to facilitate closer co-operation between the railway companies.

A number of the Indian State Railways, although treated as separate units, are co-operating in various ways — e. g., through running of stock, special through rates, the joint employment of staff at interchange points, and in some cases the division of competitive traffic. The Indian Railway Conference Association acts as a link between the various railways.

In Netherlands Indies all freight traffic between the stations of the State Railways and those of other railways is subject to agreements as to working and the distribution of receipts between the interested railways. Passenger traffic over the most important routes is similarly co-ordinated.

In other countries where the railways are under the single control of a state authority the question of co-ordination hardly arises.

### (b) Co-ordination of road and rail transport.

My review of changes in commercial policy has largely been concerned with what might be termed the domestic railway interests, and in bringing my comments to a close, reference should be made to measures taken in the direction of co-ordinating the conflicting claims of road and rail transport interests.

The degree to which co-ordination has been attempted and the measure of success, has varied considerably from one country to another, and even from one railway administration to another, but the trend of events can possibly be gauged from the information set out hereafter.

In the first place I will deal with the co-ordination of passenger transport.

In Great Britain the four main line railway companies have, since 1928, been empowered to own and operate road transport services, but instead of introducing their own services the companies have followed the policy of purchasing an interest in existing concerns. Through this procedure the British Railways have obtained representation on the Boards of Management of Road Companies, and it has been practicable to devise machinery in the form of Standing Joint Committees representative of road and rail interests, by whom questions of co-ordination have been considered.

Among the measures adopted are :

Omnibuses making contact at railway stations.

Adjustment of omnibus and train timings to improve connectional facilities.

Provision of feeder services from outlying districts to appropriate railway stations to connect with rail excursions.

Interavailability of rail and road tickets.

Provision of combined rail and road tours.

Reciprocal publicity.

This procedure has achieved a fair degree of success, and the investments of the railway companies can also be said to be profitable.

What perhaps is the greatest attempt in the world in the co-ordination of road and rail passenger traffic is that being carried out under the aegis of the London Passenger Transport Board. The Board

was constituted under the London Passenger Transport Act, 1933, to provide an adequate and properly co-ordinated system of passenger transport in an area of 1986 square miles, and combines the ownership of omnibuses, motor coaches, tramways, trolleybuses and underground and surface railways. The Act also provides that whilst the main line railway companies shall continue to operate their own suburban passenger services in the London area, the receipts directly accruing therefrom shall be subject to a pooling scheme controlled by a Standing Joint Committee of representatives of the Board and Railway Companies.

The population of the area served by the Board numbers 9 500 000 and in the year ended June 30th, 1936, no less than 4 215 000 000 passengers were carried by the Board and by the suburban services of the main line companies within the ambit of the scheme.

Like the British Railways, the Reading Company and Central Railroad of New Jersey (U. S. A.) as well as the administrations in the Argentine have secured an interest in, or established road services through the medium of, subsidiary organisations, a course now followed by the Egyptian State Railways after having tried its own road services.

On the other hand, the State Railways of the Netherlands Indies and the Lourenço-Marquès Railway not only run their own services but collaborate with other road organisations.

Road services established through subsidiary organisations or collaborative arrangements generally appear to be, in the main, regarded as feeder services, but in a number of cases they compete directly with rail while seeking to restrict or supersede unassociated services.

In a number of countries, such as Ireland, South Africa and Indo-China, legislative action has tended to eliminate road competition, or restrict it to local significance, to such an extent that further action in the direction of co-ordination appears to be unnecessary, as existing road services are apparently now more of the nature of feeders than competitors.

Variations in practice are also noticeable in the attempts to co-ordinate road and rail interests in connection with freight traffic.

As in the case of passenger transport, legislative measures have played an important part in co-ordinating freight services in South Africa and the Irish Free State, where operations competitive with rail have apparently been brought within restricted limits. In both countries, rail administrations have introduced road services which function principally as feeders to rail.

The practice of British Railways has long been to cart freight to and from their terminals, and as already stated these services have been augmented and extended in recent years. Since obtaining road powers in 1928 the railways have introduced a limited number of regular services for freight, usually over short distances and to supplement rather than compete with rail services; in addition they have provided throughout road transport for consignments of intermittent character which otherwise would have been carried by competitive road hauliers.

Whilst exercising their legal rights in this way, the four main-line British Companies have jointly acquired two large old-established road transport organisations, and through them, a number of other concerns of less magnitude. Except to stipulate that they shall not solicit traffic already rail-borne, no restriction has been placed on these associated firms by the railway administrations, but contact is maintained through a Standing Committee of road and rail representatives who consider questions of co-ordination and any other matters affecting both interests.

In the Argentine all four reporting administrations have attempted to cater for

throughout road transport of freight by the provision of their own road services or through acquired concerns. These methods were, however, found to be unprofitable owing to the competition of unregulated owner-drivers, and an arrangement has since been introduced whereby road subsidiaries perform collection and delivery of small consignments of merchandise which are amalgamated into wagon loads for rail conveyance.

Operation by a subsidiary has been the method adopted in U.S.A. by the Reading Company and Central Railroad for competing with other road operators and for substituting unprofitable less-than-car-load trains. No existing concerns have been purchased, and the subsidiary company has provided its own fleet of vehicles. It is interesting to note that rail canvassers solicit for both rail and road conveyance, and in this manner often retain to rail what would otherwise go to other road operators, but where that is not possible they influence traffic to the subsidiary road concern, apparently with some measure of success.

In Mozambique the railway administration operates its own road services, principally as feeders, but partly with the aim of stifling competition on parallel roads, and has also concluded agreements with, or acquired interests in, other road concerns as a step towards reducing competition.

In the Netherlands Indies similar measures have been adopted, whilst in Indo-China agreements have been made with road enterprises although co-ordination there has been effected chiefly by the system of taxation introduced.

## PART VI.

# Summary and Conclusions.

### a) General.

Through the co-operation of twenty-five railway administrations in thirteen different countries who have so generously responded to my request for information, I have been able to survey in a comprehensive manner the broad trend of events from 1929 to 1935 arising from the world crisis and road competition, and changes in railway commercial policy to meet the unprecedented situation.

### b) Trend of rail traffics.

Viewed from the standpoint of rail receipts 1935 was, generally speaking, a more prosperous year than its immediate predecessors, and it is encouraging to find that the upward tendency which first became apparent in 1932 has been widely maintained, although the majority of reporting administrations have still much leeway to make up before they reach their pre-crisis position. It is, therefore, of particular interest that the Lourenço-Marquès Railway and the South African Railways realised a higher gross receipt in 1935 than in 1929.

In general, railway administrations appear to have benefited to a greater extent in their freight than in their passenger traffic, whilst the principal factor contributing to the better rail position has been the gradual recovery of industry from the world depression rather than from the stemming of the growth of road competition.

It seems to be beyond dispute that in countries where road transport has not been brought under appropriate legislative restriction, the railways have not obtained the maximum benefit from the improving industrial situation.

It is pleasing to be able to report once again that railway administrations have continued to pay close attention to the limitation of expenditure, and this com-

mendable action has materially assisted in the general enhancement of net revenue.

c) **Development of road competition.**

The degree of road competition has shewn considerable variation in different countries, and it would appear that whilst the early phenomenal growth in the number of road vehicles has somewhat abated since 1931, the newer types of freight carrying road motors are superior to their forerunners and are capable of conveying a greater pay-load in relation to tare weight.

Legislative control of road transport is a slowly developing feature and although in some countries (e.g., Kenya and Uganda, South Africa and the Irish Free State) it has virtually eliminated competition between road and rail, in others the restrictive measures have as yet only touched the fringe of the problem, whilst there are still a few instances (e. g., Mozambique) where road transport remains free from legislation in its competition against other forms of transport.

The general position is, however, still not satisfactory, and whilst various Governments appear to have realised the harmful effects of unrestricted road competition, further legislative action would seem to be necessary, not only to institute some control of road competition but also to ensure that any existing or contemplated legislation is rendered effective by adequate supervision.

d) **Changes in commercial policy.**

Determined and praiseworthy efforts have been made by various administrations to foster increasing use of the railways. In most cases they have strengthened the commercial organisation and endeavoured to inculcate a sense of salesmanship amongst the staff in order to ensure more effective contact with the public and to ascertain and satisfy as far as practicable their transport requirements.

Measures taken to attract passenger traffic have included improvements in passenger vehicles, acceleration of services, and the introduction of reduced fares, the latter, in the main, taking the form of cheap tickets of the « excursion » type rather than an all-round reduction.

In Great Britain increased and accelerated suburban passenger services have been made possible by the adoption of electric traction in areas where that form of transport is suitable.

Opinion is divided on the question of light rail units, and whilst in some countries they are already well established, and in others experiments with various types of unit are still being made, their success or otherwise is largely dependent upon local conditions.

Similarly, in the case of freight traffic, recent years have witnessed not only the improvement of existing rail services, but the gradual and, to a large degree, widespread introduction of new facilities which have all tended to make transport from door to door by railway administrations a feature of commercial practice. At the same time, railway administrations have not been unmindful of the advantage enjoyed by industrialists in the shape of lower rates by road and this has been met to a wide extent by modified tariffs and simplified methods of charging.

To bring prominently to the notice of the public the comprehensive facilities they have on offer, some of the railways have recently embarked upon intensified advertising campaigns; on the other hand, a few administrations have found it necessary to reduce this form of expenditure owing to the economic situation. Joint advertising appears to have very little application outside Great Britain, but it can be productive of some economy where two or more companies serving common territory have facilities of a similar character.

Co-ordination or co-operative working between companies has, where practic-

able, proved a source of considerable economy on the commercial as well as on the operating side, particularly in Great Britain and in the Argentine and parts of the United States of America, but its scope is limited to areas where two or more administrations are mutually concerned.

e) **Co-ordination between road and rail.**

The degree to which co-ordination between railways and road concerns has been attempted or achieved has varied considerably in different countries. In respect of passenger transport, some administrations have by outright purchase acquired almost sole control of road operations in their territory, whilst in other cases they have bought interests in road firms with representation on the Board of Management, or have entered into co-ordinated arrangements with independent road organisations. On the other hand, in a few cases little or no co-operation between rail and road appears to exist.

The most complete scheme of co-ordination of road and rail interests yet evolved is probably that of the London Passenger Transport Board in association with the four main line railways of Great Britain. The London Passenger Transport Board was constituted in 1933 and owns and operates in London and its environs, not only omnibuses, motor coaches, tramcars and trolleybuses, but also underground and surface railways over an area of 1 986 square miles (in much of which it is monopolistic) with a resident population of 9 500 000. Under the terms of the London Passenger Transport Act, the services of the Board are operated in close harmony with the suburban services of main line railways within the Board's area, the receipts being subject to a pooling arrangement.

Similar variations in practice are apparent in the attempts at co-ordination in respect of freight traffic. Some administrations have powers to operate their own road services, and do actually operate them, but others, whilst having similar powers, deem it to be prudent to delegate road transport to subsidiary concerns. In the main, road services in which railway administrations are wholly or partially interested are utilised as feeders to rail, although in a number of cases they compete against rail and road operators impartially.

f) **Conclusions.**

Viewing the whole of the evidence before me, one can summarise the trend of events as shewing that the influence of the world depression is definitely, but in some cases slowly, waning, and it no longer dominates the situation.

The competition of road transport, however, continues in varying degree to exercise an adverse effect upon the railway position, and must be regarded as a permanent factor in the field of transport. The question as to its rightful place in that field cannot yet be said to have been answered with any degree of finality. That the various forms of transport should be complementary rather than competitive is a precept which has already received considerable recognition in well-informed circles in several countries, but its translation into practice constitutes a problem which as yet has been hardly approached.

In the present state of affairs it needs to be emphasised that there is still a wide disparity between the liberties enjoyed respectively by the two forms of transport and much remains to be done by discerning and rational legislation to remedy this position and create an atmosphere conducive to co-ordination on sound lines.

In the difficult situation which has clearly prevailed in most countries in this respect, I should like once more to pay tribute to the courageous and long-sighted view taken by railway administrations in their approach to a problem of great complexity where precedent could afford little or no guidance.

[ 625. 14 ]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

QUESTION I.

# The construction of modern track to carry heavy loads at high speeds, and methods of modernising old track for such loads and speeds.

# Facing points which can be taken at high speeds.

## REPORT

*(Germany, Austria, Belgium and Colony, Denmark, Finland, Hungary, Luxemburg, Norway, Netherlands and Colonies, Poland, Sweden, Switzerland),*

by C. LEMAIRE,
Directeur du Service de la Voie, Belgian National Railways Company.

CONTENTS.

Pages

FOREWORD . . . . . 358/104

PART ONE : **The construction of modern track to carry heavy loads at high speeds and methods of modernising old track for such loads and speeds.** 359/105

CHAPTER I. — **Characteristics of present-day vehicles.** »

*The vertical loads imposed by vehicles on the track* . . . . . »

*a*) The axle loads . . . . . »

*b*) The total weight of the vehicles . . . . . 364/110

*c*) Characteristics of the vehicles affecting their running over bridges and other structures . . . . . »

*d*) The actual forces exerted by vehicles in motion . . . . . 368/114

*The lateral thrust of vehicles on the track* . . . . . »

*e*) The conditions governing the passage of vehicles over curves . . . . . »

*The effect of speed on the track* . . . . . 372/118

*f*) Vehicles and trains moving at high speeds . . . . . »

CHAPTER II. — **Present-day main-line permanent way.** 374/120

*Rails* . . . . . »

*a*) Rail manufacture and inspection . . . . . »

*b*) Section and length of rails used on main lines . . . . . 382/128

*c*) Regulations governing the removal of rails from the track and the methods used to delay it . . . . . 389/135

*Rail joints* . . . . . 393/139
a) Design of rail joints . . . . . »
b) Width of rail joints . . . . . 394/140

*Sleepers* . . . . . »
a) Laying plan and sleeper spacing . . . . . »
b) Nature and characteristics of sleepers used . . . . . »

*Rail fastenings* . . . . . 401/147
*Ballast* . . . . . 402/148
*Formation* . . . . . 407/153
*Bridges and other structures* . . . . . »
*Curves* . . . . . 408/154
a) Gauge on curves . . . . . »
b) Lay-out of the track on curves . . . . . »
c) Superelevation on curves . . . . . »
d) Speed restrictions on curves . . . . . 409/155

CHAPTER III. — **Modernising old track for heavy loads and high speeds** . . . . . 423/169

Modernising the track for heavy loads . . . . . »
Modernising the track for high speeds . . . . . »

PART TWO : **Facing points which can be taken at high speeds** . . . . . 425/171

CHAPTER I. — **Lay-out** . . . . . »

CHAPTER II. — **Points and crossings** . . . . . 429/175

*Points* . . . . . »
*Crossings* . . . . . 430/176

CHAPTER III. — **Conditions under which points and crossings are laid and run over** . . 434/180

*General safety measures* . . . . . 437/183

SUMMARY . . . . . »

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## FOREWORD.

In order to simplify the task of the special reporter and to make the discussions easier and more methodical, we have adopted the same procedure as that followed by Mr. H. FLAMENT, Ingénieur en chef-adjoint des Travaux et de la Surveillance, of the French Nord Railway.

We have refrained from expounding the same points, in order to direct attention more specially to others, and thereby imbue the debates with a maximum of interest.

Modernising the permanent way is not solely a technical problem, but also and primarily an economic one, which confronts the Railway Administrations, in view of road, water and even air competition. This is why we also wish to express our fullest thanks to the Admi-

nistrations (1) for their kind collaboration towards the investigation of this vital problem.

* * *

# PART ONE.

## The construction of modern track to carry heavy loads at high speeds and methods of modernising old track for such loads and speeds.

The track is subjected to ever-increasing static and dynamic stresses resulting from the heavier axle loads of the vehicles it carries, and from the increasing speeds.

From the point of view of resistance to the stresses the rail acts as a continuous beam on elastic supports.

It is possible, on the basis of certain assumptions, notably as regards the sinking of the sleepers into the ballast whilst under load, to embark upon calculations for the dimensions to be given to the rails, allowing for stationary or slowly moving vehicles

But the problem is principally a dynamic one, since at high speeds the rail acts to some extent as a vibrated riband.

Experience in this connection plays a preponderating part.

For example, it is experience which has led the majority of the Railways to reduce the spacing of the sleepers, rather than increase appreciably the weights of the rails. It is also as a result of experience that the Railways have found that a strongly built track leads to a considerable reduction in maintenance costs which more than compensates for the interest and amortization charges due to the additional first cost.

The best solution to the problem confronting us is therefore to be found in the common experience of the railways. We are thus naturally led to examining in the first instance, the characteristics of the vehicles which are to travel on the track and the maximum speeds at present authorised and contemplated in the near future.

* * *

## CHAPTER I.

### Characteristies of present-day vehicles.

#### Vertical loads imposed by the vehicles on the track.

a) **Axle loads.**

The following question has been propounded :

What are the present maximum axle loads of the different classes of vehicles : steam locomotives, electric locomotives, high-capacity goods wagons, railcars, passenger carriages and other vehicles?

Should these axle loads be increased and to what extent?

The particulars received on the subject of maximum axle loads, as already permitted and possibly contemplated, for the various categories of vehicles, are brought together in Table 1.

The heaviest axle loads of vehicles in service on the Railways consulted are :

24 t. (23.6 Engl. tons) for the 4-6-2 type steam locomotives of the *Belgian National Railways Company,*

21.6 t. (21.26 Engl. tons) for the 8/14 type electric locomotives of the *Swiss Federal Railways,* represented in Table 2. These locomotives are fitted with a device for increasing the adhesion; the load on the driving axles (19.8/19.9 t. = 19.5/19.6 Engl. tons), when starting, can be increased to 21.5/21.6 t. (21.16/21.26 Engl. tons), causing the intermediate car-

(1) Our thanks are also extended to two of our collaborators namely, Messrs, R. Campus, Ingénieur en chef, and M. Masuy, Ingénieur, Permanent Way Department, Belgian National Railways Company.

TA

## Maximum axle loads allowed at pre

*In metric tons –*

| ADMINISTRATIONS. | Steam locomotives. | Electric locomotives. | High-capaci goods wago |
|---|---|---|---|
| *Deutsche Reichsbahn* . . . . . | 20 t. + 5 % toler. | 20 t. + 5 % toler. | 20 t. + 5 % t |
| *Austrian Federal Rys.* . . . . . | 18 | 20 | 18 |
| *Belgian National Rys. Co.* . . . . | 24 | None. | 18<br>20<br>(A few vehic |
| *Danish State Rys.* . . . . . | 19 | None. | 14.7 |
| *Netherlands Rys.* . . . . . | 18.5 | None. | 17.8 |
| *State Rys. in the Dutch Indies.* . . | 12 | 13.5 | 11.8 t. 4-whe<br>10 t. 8-whee |
| *Hungarian State Rys.* . . . . . | 16.36 | 18.5 | 11.5<br>16.16 t. 4-whe |
| *Swedish State Rys.* . . . . . | 17.5 | 17 | 16 |
| *Union of Swedish Private Rys.* . . | 16 | None. | 16 |
| *Bergslagen Ry. (Sweden)* . . . . | 18 | None. | 22.5 |
| *Swiss Federal Rys.* . . . . . | 17.6<br>The Swiss Federal Rys. no longer order any steam locomotives. | 21.5 | 16 for S.F.R. v<br>20 for foreign<br>allowed to run<br>S.F.R. lines. |
| *Berne-Loetschberg-Simplon Rys.* . . | ... | 20 | 20 |
| *Polish State Rys.* . . . . . | 18.15 | None. | 16 |

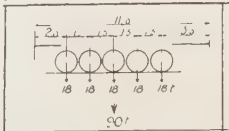
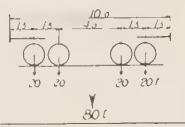
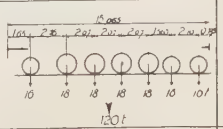
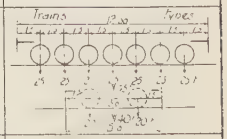
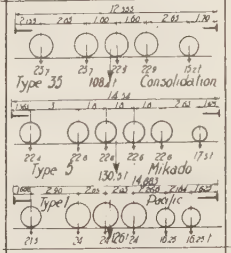
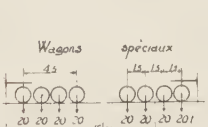
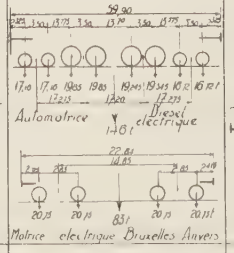
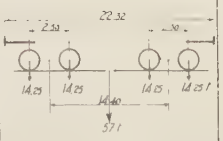
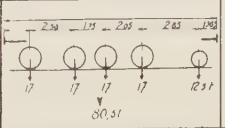
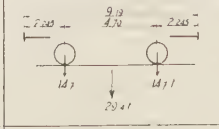
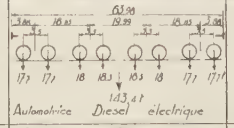
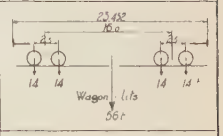
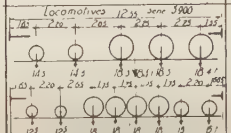
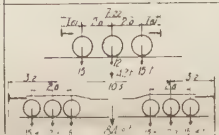
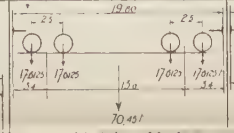
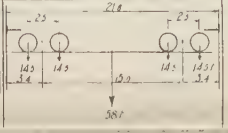
## y the various Railways.

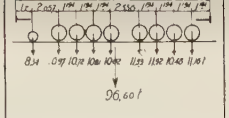
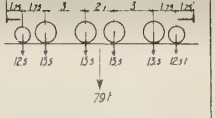
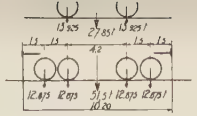
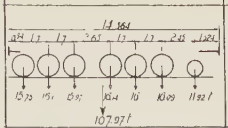
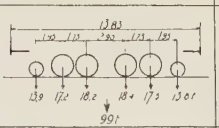
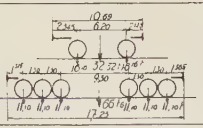
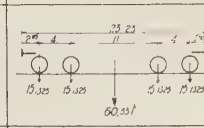
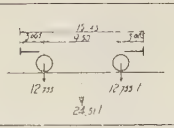
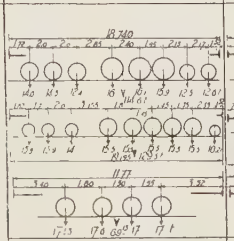
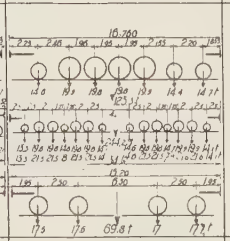
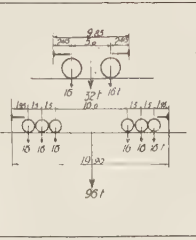
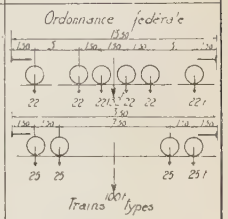
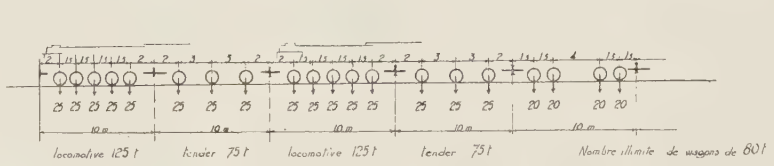
*0.984 Engl. ton.*

| Railcars. | Passenger carriages. | Various vehicles, breakdown equipment, etc. | Contemplated increase. | REMARKS. |
|---|---|---|---|---|
| t. + 5 % toler. | 20 t. + 5 % toler. | ... | None. | ... |
| 14.6 | 14 | ... | Yes. | ... |
| 24 (20.75) (1) | 18 | ... | None. | (1) Figures between brackets represent the maximum axle load reached at present. |
| 18.3 | 14 approx. | ... | None. | ... |
| 17.5 | 14.5 | ... | None. | ... |
| 12.8 | 9.7 | ... | None. | ... |
| 15.1325 | 12.755 | ... | Yes, up to 25 tons. | ... |
| None. | 16 | ... | Yes, up to 18 tons. | ... |
| None. | 16 | ... | ... | ... |
| None. | 22.5 | ... | ... | ... |
| 17.7 vehicles running at speeds not exceeding 90 km./h. 10 railcars allowed to run at 125 km./h. | 16 | ... | None. | ... |
| 12 | 20 | ... | None. | ... |
| 10 | 14 | ... | None. | Special steels will be used shortly in rolling stock construction. |

TABLE 2.

## Total weight (metric tons) of the heaviest vehicles and diagrams of weight distribution.

| ADMINISTRATIONS. | Steam locomotives. | Electric locomotives. | High-capacity goods wagons. | Railcars. | Passenger carriages and other vehicles. | Miscellaneous Breakdown cranes, etc. |
|---|---|---|---|---|---|---|
| *Deutsche Reichsbahn.* |  | |  | | | |
| *Austrian Federal Rys.* |  | 119 tonnes | 72 tonnes | | |  |
| *Belgian National Rys. Co.* |  | |  |  |  | |
| *Danish State Rys.* |  | |  |  | |  |
| *Netherlands Rys.* |  | |  |  |  | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *State Rys. in the Dutch Indies* . . . . . |  |  |  | | 38 t tonnes Longueur 18 m | |
| *Hungarian State Rys.* . |  |  |  |  |  | |
| *Swedish State Rys.* . . | 89 tonnes | 80 tonnes | | | | |
| *Union of Swedish Private Rys.* . . . . . | 40 tonnes | 40 tonnes | 40 tonnes | 38 tonnes | 38 tonnes | |
| *Bergslagen Ry. (Sweden)* . . . . . | 131.1 tonnes | | 44.8 tonnes | | | |
| *Swiss Federal Rys.* . |  |  |  | | |  |
| *Berne-Loetschberg-Simplon Rys.* | locom. électriques Be 6/8 : 143 t | | | | | |
| *Polish State Rys.* . . | 113.8 t. (sans tender) | | 60 tonnes | 40 tonnes | 64 tonnes | |
| *Belgian National Rys. Co.* Standard train. |  | | | | | |

*Note:* Trains-types = standard trains. — Automotrice = railcar. — Wagons spéciaux = special wagons. — Motrice électrique = Electric motor coach. — Wagons-lits = sleeping car. — Ordonnance fédérale = Federal ordinance. — Nombre illimité... = Unrestricted number of 80-t. wagons

rying axles to be correspondingly unloaded.

20 t. (19.7 Engl. tons) for goods wagons of the *Deutsche Reichsbahn* and the *Belgian Nat. Rys. Co.*

20.75 t. (20.42 Engl. tons) for the electric motor coaches of the *Belgian Nat. Rys. Co.* (Brussels-Antwerp high-speed electrified line).

Out of 13 Administrations consulted, only three intend to increase the maximum authorised axle load, but none, with the exception of Hungary, contemplate greater loads than those already reached on other railways. The *Royal Hungarian State Railways* are of the opinion that it would be desirable to raise the maximum axle load to 25 tons for electric locomotives.

It should be noted that several Railway Administrations design their bridges and other structures on the main lines for a standard train made up of a given number of locomotives and wagons with heavier axle loads than the maximum permitted at present.

The *Austrian Federal Railways* calculate their bridges on the basis of each track carrying a train composed of three locomotives coupled together, preceded and followed by wagons, as shown by the diagrams in the column headed « Miscellaneous » of Table 2.

The *Swiss Federal Railways* specify, when designing the more important bridges on the main lines, a standard train composed of three locomotives and an unrestricted number of wagons, corresponding to the diagrams shown in the « Miscellaneous » column of Table 2.

The *Belgian Nat. Rys. Co* designs the new bridges to carry the loads of the standard train illustrated in Table 2.

In order to take into account the effects of springs and variations in the counter-balancing of locomotive wheels and in anticipation of the increase in the axle loads, the members of metal bridges which directly carry the train — rail bearers, cross girders, braces or beams — as well as the main girders for short spans, are designed to carry live load arrangements consisting either of a single load of 28 tons, or two loads of 27 tons, 1.50 m. (4′ 11″) apart, or three loads of 26 tons, the same distance apart, in so far as these arrangements produce greater stresses than those produced by the standard train.

### b) Total weight of vehicles.

The question put is the following :

What are at the present time, for the various categories of vehicles indicated in paragraph 1 the total weights in running order of the heaviest vehicles and what is the distribution rule or diagram of the loads along the length of the vehicle?

The data gathered on this subject are presented in Table 2.

### c) Characteristics of the vehicles affecting their running over bridges and other structures.

The question circulated was worded as follows :

What are the modern vehicles which show the most unfavourable weight distribution as regards running over bridges and structures?

Please briefly state their principal characteristics and any restrictions imposed on their working?

The information supplied in reply to this question has enabled us to draw up Table 3 in which

P = maximum axle load,

A = shortest wheel base,

L = total length over buffers.

The ratio $\frac{P}{A}$ gives the heaviest load per linear metre;

The ratio $\frac{\Sigma P}{L}$ gives the average load per linear metre.

An examination of this table shows that the vehicles having the most unfavourable loading conditions as regards their passing over bridges are the following :

| — | P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ |
|---|---|---|---|
| | | *(Metr. t.)* | |
| (a) *Steam locomotives :* | | | |
| 4-6-2 locomotive of the Deutsche Reichsbahn | 18 | 13.33 | 8 18 |
| 4-6-2 locomotive of the Belgian National Railways Co. | 24 | 11.71 | 8.47 |
| 2-8-2 locomotive of the Belgian National Railways Co. | 22.8 | 12.67 | 8.98 |
| 2-8-0 locomotive of the Belgian National Railways Co. | 23.7 | 14.81 | 8.77 |
| (b) *Electric locomotives :* | | | |
| Ae 4/7 electric locomotive of the Swiss Federal Railways | 19.9 | 10.2 | 7.36 |
| Ae 8/14 electric locomotive of the Swiss Federal Railways | 21.6 | 12.34 | 7.18 |
| (c) *Goods wagons :* | | | |
| 80-ton wagons of the Deutsche Reichsbahn | 20 | 13.33 | 8 |
| Special 160-ton well wagons of the Belgian National Railways Co. | 20 | 13.33 | 7 |
| (d) *Rail motor coaches :* | | | |
| Electric motor coaches of the Netherlands Railways | 17.6125 | 7.045 | 3.56 |
| Electric motor coaches of the Belgian National Railways Co. | 20.75 | 7.28 | 3.63 |
| Diesel-electric motor coaches of the Danish State Railways | 18.3 | 5.55 | 2.24 |
| Diesel-electric motor coaches of the Belgian National Railways Co. | 19.85 | 5.67 | 2.44 |
| (e) *Passenger coaches :* | | | |
| Passenger coaches of the Netherlands Railways | 14.50 | 5.8 | 2.66 |
| All-metal coaches of the Belgian National Railways Co. | 14.25 | 5.7 | 2.55 |

## Characteristics of the vehicles with the most unfavoural

| ADMINISTRATIONS. | Steam locomotives. | | | Electric locomotives. | | | High-capacity goods wagons. | | |
|---|---|---|---|---|---|---|---|---|---|
| | P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ | P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ | P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ |
| | Metr. t. | Metr. t. p. metre | | Metr. t. | Metr. t. p. metre | | Metr. t. | Metr. t. p. metre | |
| *Deutsche Reichsbahn* | 20 | 13.33 | 8.18 | 20 | ... | ... | [20] | [13.33] | [8 |
| *Austrian Federal Rys.* | 18 | 11.50 | 7.97 | 20 | ... | 6.19 | 18 | ... | 7 |
| *Belgian National Rys. Co.* | [24]<br>22.8<br>23.7 | 11.71<br>12.67<br>[14.81] | 8.47<br>[8.98]<br>8.77 | ... | ... | ... | [20] | [13.33] | |
| *Danish State Rys.* | 19 | ... | 6.63 | ... | ... | ... | Tank wagons.<br>16 | ... | |
| *Netherlands Rys.* | 18<br>18.4 | 10.3 | 7.3 | ... | ... | ... | 15.16 | 10.8 | 5 |
| *State Rys. in the Dutch Indies.* | 12 | ... | 7.1 | 13.5 | ... | 5.37 | ... | ... | ... |
| *Hungarian State Rys.* | 16.14 | 9.49 | 7.53 | 18.4 | 10.64 | 7.15 | 16.16<br>11.1 | 8.54 | 3. |
| *Swedish State Rys.* | ... | ... | ... | ... | ... | ... | ... | ... | .. |
| *Union of Swedish Private Rys.* | ... | ... | ... | ... | ... | ... | ... | ... | .. |
| *Bergslagen Ry. (Sweden* | ... | ... | ... | ... | ... | ... | ... | ... | .. |
| *Swiss Federal Rys.* | 15.5<br>17.6 | 10.7<br>11.7 | 6.72<br>5.87 | 19.9<br>[21.6] | 10.2<br>[12.34] | [7.36]<br>7.18 | 16 | 10.66 | 4 |
| *Berne-Loetschberg-Simplon Rys* | ... | ... | ... | ... | ... | ... | ... | ... | .. |
| *Polish State Rys.* | ... | ... | ... | ... | ... | ... | ... | ... | .. |

## distribution as regards running over bridges.

| Railcars. | | | Passenger carriages and other vehicles. | | | Miscellaneous: Railbuses, breakdown equipment. | | | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|
| P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ | P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ | P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ | |
| tr. t. | Metr. t. p. metre | | Metr. t. | Metr. t. p. metre | | Metr. t. | Metr. t. p. metre | | |
| 20 | ... | ... | 20 | ... | ... | ... | ... | ... | ... |
| .6 | ... | ... | 14 | ... | ... | ... | ... | ... | ... |
| 0.85 esel-electric railcar | 5.67 | 2.44 | | | | | | | |
| 0.75 ectric motor coach. | 7.28 | 3.63 | 14.25 | 5.7 | 2.55 | ... | ... | ... | ... |
| | | | | | | Sleeping cars. | | | |
| 18.3 esel-electric railcar | 5.55 | 2.2 | ... | ... | ... | 16 | ... | 5 | Maximum authorized axle load : 20 t. Speed restricted where required, according to condition of bridges. |
| .6125 lectric motor coach | 7.045 | 3.56 | 14.5 | 5.8 | 2.66 | ... | ... | ... | ... |
| ... | ... | ... | 19.4 | 8.2 | 2.1 | ... | ... | ... | ... |
| .1325 | 3.78 | 2.60 | 12.755 | ... | 1.65 | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | Unfavourable distribution of loads is avoided. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | No restrictions. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | No restrictions. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | No conditions. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | Do not own such types. |

The characteristics of the standard trains are as follows :

| — | P | $\frac{P}{A}$ | $\frac{\Sigma P}{L}$ |
|---|---|---|---|
| | *(Metr. t.)* | | |
| 1. *Locomotives :* | | | |
| Standard train of the *Austrian Federal Railways* | 25 | 16.67 | 14.58 |
| Standard train of the *Swiss Federal Railways* | 22 | 14.67 | 9.78 |
| Standard train of the *Belgian National Railways Co.* | 25 | 16.67 | 12.50 |
| 2. *Wagons :* | | | |
| Austria | 20 | 6.67 | 6.67 |
| Switzerland | 25 | 16.67 | 7.41 |
| Belgium | 20 | 13.33 | 8.00 |

d) **Actual forces set up in the track by vehicles in motion.**

The strain to which the track is subjected is increased by the forces transmitted to the axles, by the propelling machinery, by the inertia forces of the moving parts connected to the wheels, by inequalities, however slight, in the rail level, by the unequal distribution of the weight of an axle between its two wheels, and by the sudden load applied by trains at speed.

Measurements have been made in the track of the *Belgian Nat. Rys. Co.* with a recording extensometer of great precision (1). This extensometer was fixed on the foot of the rail in the space between two sleepers, as near as possible to a rail joint.

These tests show that the stresses set up are little influenced by speed, unlike what might be expected « a priori ». This fact is undoubtedly attributable to the elasticity of the ballast.

However, since only a few tests were made, we are not inclined to draw any definite conclusions from them; they are mentioned for the sake of information.

(1) D.V.L. (Deutsche Versuchs Anstalt für Luftfahrt) extensometer.

We hope that the Railways will see their way clear to make direct observations on their roads, under various loading conditions, with the precision instruments which ingenious makers have placed at the disposal of experimenters.

## Lateral thrust of the vehicles on the track.

e) **The conditions governing the passage of vehicles over curves.**

The running of vehicles over curves sets a problem the importance of which increases in proportion as high commercial (overall) speeds are becoming current practice.

Each new stage in the attainment of higher speeds compels manufacturers of railway equipment to increase the motive power and to improve the standard of safety and comfort offered to passengers.

The builders are also under the necessity of constantly adding to the lengths of locomotives and rolling stock, and augmenting the axle loads.

On the *Belgian Nat. Rys. Co.*, in the latest locomotives, the wheel base (between extreme axles) is 11.45 m.

(37′ 7″) and the maximum axle load 24 t. (23.2 Engl. tons) whilst the length of the metal coaches was fixed at 22 m. (72′ 2 1/8″) (excluding buffers).

Consequently special precautions must be taken when designing modern vehicles as well as when laying the track, in order to avoid making curve negotiation more difficult.

In vehicles, the problem of curve negotiation is solved by the generalised use of the bogie.

There are, however, two factors opposing the vehicles being lengthened indefinitely :

1. The reduction in width of the vehicle to prevent excessive overhang of the middle and ends of the body whilst passing round curves.

The extent to which rolling stock can be lengthened is necessarily limited by these reductions in width, since these imply a diminution of capacity and comfort, which is contrary to the desired object.

2. The relative transverse displacement of the buffers of two coupled vehicles. This reaches its greatest magnitude when the vehicles are passing over a point of tangency in the track or over a short straight section between two reverse curves. The transverse displacement of the buffers increases in proportion to the length of the overhanging part of the vehicles. If the radius of the curves is sufficiently small, the two buffers may clear one another, become locked, and derail the vehicles.

When all-metal coaches [total length, exclusive of buffers = 22 m. (72′ 2 1/8″), overhang = 3.25 m. (10′ 8″), diameter of buffers = 0.51 m. (20 1/16″)] were introduced on the Belgian Nat. Rys. Co., the question of buffer locking was specially investigated, as a result of which the following instructions have been issued in connection with the lay-out of the track :

*a*) Between two reverse curves, not provided with transitions, a straight section should be interposed whose length varies from 14 m. (45′ 11″) to 0 m. as the radius varies between 150 and 300 m. (7 1/2 and 15 chains).

*b*) The minimum width of six-foot way in slip points must not be less than 2.25 m. or 2.50 m. (7′ 4 19/32″ or 8′ 2 7/16″), depending on whether the angle of tangency of the slip-points or simple points as designed is 0.1086 or 0.125 if the rakes have to take the branching-off roads in opposite directions of two successive switches.

As far as the locomotives are concerned, their flexibility has been increased generally by giving the driving axles more play, by the thinning down of certain wheel flanges, and the use of bogies or trucks with more and more play.

From the particulars we have collected and which are summarized in Table 4, it seems hardly possible to deduce any definite relationship between the rigid wheel-base and the lateral play of the axles or groups of axles.

The relative values of these two important factors, as regards negotiating curves and the good behaviour of the track appear to have remained empirical, although the object desired is generally the same on all railways : « to ensure negotiation of curves of a radius not under 150 m. (7 1/2 chains) ».

The running of locomotives unto the branching off part of points and crossings is another question which deserves attention. There is usually greater difficulty in running through the curved parts of points and crossings than through curves in the running road, particularly when the points are located on a curve or preceded by a curve of relatively small radius.

The increased difficulty at the entry to switches, at the point blade, must be attributed to the deviation of the latter, since an angle is introduced into the path to be followed by the wheels.

Formerly the need for short switches predominated; switches of considerable

## Vehicles with the most unfavoural

| ADMINISTRATIONS. | Types of vehicles. | Rigid wheelbase (W. B.) (metres). |
|---|---|---|
| *Deutsche Reichsbahn* . . . . . | Steam locomotives.<br>Goods wagons. | Wagons for bulky goods have rigid wheel-base. |
| *Austrian Federal Rys.* . . . . . | Steam locomotives.<br>Electric locomotives.<br>Goods wagons.<br>Railcars. | 5.70<br>5.67<br>4.50<br>7.00 |
| *Belgian National Rys. Co.* . . . . | Steam locomotives.<br>Goods wagons.<br>Railcars. | No restriction.<br>Curves of R = 150 m. can be negotiated.<br>8.50 |
| *Danish State Rys.* . . . . . | Steam locomotives.<br>Goods wagons.<br>Passenger carriages.<br>Railcars. | 4.60<br>4.20<br>4.27<br>Articulated. |
| *Netherlands Rys.* . . . . . | Steam locomotives.<br>Bogie wagons.<br>Other wagons.<br>Carriages. | Series 6300 W. B. = 5.<br>Series 3900 W. B. = 4.<br>Unrestricted.<br>10 m.<br>Sufficient play in axles to allow running over R = 150 m. curve<br>Minimum : 2 m.<br>Maximum : not laid down. |
| *State Rys. in the Dutch Indies.* . . | Steam locomotives.<br>Electric locomotives.<br>Goods wagons.<br>Passenger carriages. | 3.75<br>3.00<br>3.00<br>2.36 |
| *Hungarian State Rys.* . . . . . | Steam locomotives.<br>Electric locomotives.<br>Goods wagons.<br>Railcars.<br>Passenger carriages. | 4.30<br>6.36<br>2.60<br>4.00<br>9.30 |
| *Swedish State Rys.* . . . . . | Steam locomotives.<br>(2b1). | 3.95<br>Total wheel-base = 11.10 m. |
| *Union of Swedish Private Rys.* . . | Steam locomotives.<br>Goods wagons.<br>Railcars.<br>Passenger carriages. | 4.15<br>4.50<br>4.50<br>4.50 |
| *Bergslagen Ry. (Sweden)* . . . . | Steam locomotives.<br>Goods wagons.<br>Railcars.<br>Passenger carriages. | 4.10<br>4.50<br>4.50<br>4.50 |
| *Swiss Federal Rys.* . . . . . | Steam locomotives.<br>Electric locomotives.<br>Goods wagons. | No rigid wheel-base.<br>6.50 |
| *Berne-Loetschberg-Simplon Rys.* . . | $AB^3$, $C^3$<br>6-wheeled carriages. | 9.20 |
| *Polish State Rys.* . . . . . | Steam locomotives.<br>Goods wagons. | 6.00<br>4.50 |

## aracteristics as regards negotiating curves.

| Lateral play (P) of axles or groups of axles. (Millimetres). | Other characteristics. | Restrictions on running. | REMARKS. |
|---|---|---|---|
| Maximum transverse play either side of a medium position :<br>End axles : ± 22 mm.<br>Intermediate axles : ± 31 mm. | ... | New vehicles must be built to take curves of 150 m. radius. | ... |
| 10 mm. | Longitudinal play : 18 mm. | ... | ... |
| 11 mm. | ... | ... | ... |
| 6 to 8 mm. in roller bearings.<br>10 mm. in plain bearings.<br>Up to 25 mm. in bogie bolster. | ... | ... | ... |
| Lateral play :<br>Wagons.<br>Number of wheels. / Wheel-base in mm. / Lateral play in mm.<br>4 — 4.5 to 6 — 8.5.<br>6 — 4.5 to 10 — 8.5 end axles.<br>6 — 6 to 10 — 31.5 intermed. axles.<br>Carriages.<br>Lateral play of bolster beam : 25 to 40 mm. | ... | ... | The longest distance between bogie wheel centres is 18.50 m. |
| 2 × 1 mm. | ... | ... | ... |
| High-capacity goods wagons = 2 to 5 mm.<br>Rancars, new condition = 0.5 mm.<br>Passenger carriages = 24 to 27 mm.<br>Goods wagons = 17 to 20 mm. | ... | ... | ... |
| Bogie = 55 mm.<br>Trailing carrying axle = 55 mm. | ... | ... | ... |
| 15 mm. | ... | ... | ... |
| 15 mm. | ... | ... | ... |
| 20 to 70 mm. for the bogies.<br>10 to 150 mm. for the bogies. | ... | No restrictions on curves of the S. F. R. System.<br>Restrictions on certain structures and leaf bridges. | No particular remarks concerning steam trains. |
| 10 mm. | ... | ... | ... |
| 30 mm. | ... | ... | ... |

angular deviation were therefore the rule, the resulting difficulties in the way of running through them being mitigated by gauge widening in line with the point of the blades.

Switches of such designs were soon discarded when trains had to be run at high speeds over the curved parts of points.

Modern points and crossings have to be designed so as to avoid as far possible any sudden change in direction of the path which the axles must follow, and to guide them in the best possible way by reducing to a minimum the play of the axles between the rails.

**The effect of speed on the track.**

f) **High-speed train working.**

The following questions have been put :

What is as a rule, on your lines, the maximum speed of vehicles on which there is no restriction?

Have you any intention of raising the maximum speeds and for what classes of vehicle?

The majority of the Railways consulted restrict the speed of trains of ordinary composition to 90/100 km. (56/62 miles) an hour.

Only on the German, Belgian, Danish, and Polish Railways do speeds reach 120 km. (75 miles) an hour.

There is a tendency to allow railcars or motor trains to run at specially high speeds. The difference in speed, as compared with that of an ordinary train, varies considerably according to circumstances; in Switzerland it reaches 25 km./h. (15.5 miles), i. e. 125 instead of 100 km. (78 instead of 62 miles), and in Germany 40 km./h. (25 miles), i.e. 160 instead of 120 km. (100 instead of 75 miles). We presume that the discrepancy mentioned is due primarily to the relative power of the different types of engines, sometimes also to the permanent way having sufficient strength to carry railcars of light construction, whereas it would not stand the heavier loads of locomotives running at the same speed.

The replies from the Railways do not mention these circumstances; but we can state that as far as the main lines of the Belgian Railways are concerned, there is nothing to prevent in principle, heavy steam or electric trains being run at the same speed as the motor trains.

It is noteworthy that no Administration records any outstanding performance made by electric trains with overhead contact line.

Several railway systems are taking steps to raise the speed limits; the Swiss railways intend to do this only in respect of light steam trains or motor trains.

The new limit towards which tend the efforts being made is 140 km. (87 miles) per hour, already reached (and even exceeded) in Germany by rail motor coaches, and authorised in Belgium, as a trial, for steam trains, on a section of the Brussels-Ostend international line.

As regards the possibility of reaching a higher speed than that normally practised on a given type of road, we think it worth mentioning a series of trials which were carried out, about the year 1930, simultaneously by the Dresden Division of the *Reichsbahn*, and on the *Netherlands Railways*. An account of these trials by Mr. Ch. Driessen, Chief Engineer, Permanent Way Department, Netherlands Railways, appeared in the review *Spoor- en Tramwegen*, 4th and 18th October and 1st September 1931 numbers. The result of this investigation was that the speed factor affects the track by increasing the static and compression stresses in the ratio

$$\left(1 + \frac{V^2}{30\ 000}\right)$$

* * *

TABLE 5.

## Maximum speeds being run, and under consideration.

(T = Trains. S = Steam. E = Electric. Rc = Railcars. F.M.T. = Fast motor trains)

| ADMINISTRATIONS. | Maximum authorized (km./h.) | Maximum speed under consideration (km./h.) | REMARKS. |
|---|---|---|---|
| *tsche Reichsbahn* . . . . . | S.T. 120 F.M.T. 160 | T. 140 T.A.R. 180 | Present working speeds were introduced in 1934. |
| *trian Federal Rys.* . . . . . | T. 100 Rc. > 100 | Still uncertain. | ... |
| *gian National Rys. Co* . . . . | S.T. E.T. F.M.T. } 120 | S.T. E.T. F.M.T. } 140 | As a trial, the speed of 140 km./h. is allowed on the Ghent-Bruges section. |
| *ish State Rys.* . . . . . | T. F.M.T. 120 | No change. | ... |
| *herlands Rys.* . . . . . | S.T. F.M.T. 100 | No change. | ... |
| *e Rys. in the Dutch Indies.* . . | T. 90 | Increased speed as and when new locomotives are built. | ... |
| *ngarian State Rys.* . . . . . | S.T. E.T. 100 | S.T. E.T. 120 | ... |
| *edish State Rys.* . . . . . | T. 95 | No change. | ... |
| *ion of Swedish Private Rys.* . . | T. 90 | No change. | ... |
| *ergslagen Ry. (Sweden)* . . . | T. 100 | No change. | ... |
| *iss Federal Rys.* . . . . . | S.T. 100 Light T. 110 Rc. 125 | Increased speed of fast light trains, railcars and light motor trains. | ... |
| *rne-Loetschberg-Simplon Rys.* . . | T. 90 | Possibly increased speed for light railcars. | ... |
| *ish State Rys.* . . . . . | 120 | S.T. 140 | ... |

CHAPTER II.

## Present-day main-line permanent way.

### Rails.

#### a) Rail manufacture and inspection.

In order to stand up against present-day working conditions, the railways have had to equip their main lines with high-grade materials, capable of standing up in a normal way under the multiple static and dynamic stresses resulting from the continually increasing rolling loads and speeds.

Amongst these materials the rail is clearly the fundamental element, as it receives directly from the tyres all the forces developed by the moving masses. Safety in working and the cost of the track therefore largely depend upon the quality of the rail and its resistance to breaking and to wear.

For more than ten years the main-line railways have concentrated their efforts towards improving the quality of the rails with a view to reducing the number of fractures and other damage occurring in service and to improving the resistance to wear.

This problem has already appeared in its various aspects, on the agenda of previous International Congresses, notably in London in 1925, and Madrid in 1930. It therefore seems opportune to review here the measures taken to obtain the desired objective.

*Rail manufacture.*

The first question is the following :

What process is used in manufacturing the steel for new rails to be laid on main lines? Give details of the kind and general composition of the metal.

Thirteen administrations, representing nine different countries, have replied more or less fully to this question.

The replies are summarized in Table 6 from which it will be seen that all the known processes are resorted to for the manufacture of rails, for reasons which are as much economic as technical.

In *Germany* the process adopted is either the Thomas (basic) or the Siemens-Martin, without any special requirements as to the chemical composition. The only provision is that the tensile strength should not be less than 70 kgr. (44.4 Engl. tons per sq. in.) .

The *Austrian* and *Hungarian* Railways accept only Siemens-Martin steel for their rails, with 0.3 to 0.7 % carbon and 0.8 to 1.4 % manganese, and a minimum tensile strength of 65 kgr. (41.3 Engl. tons per sq. in.) to the very hard steel exceeding 80 kgr. (50.8 Engl. tons per sq. in.).

The *Belgian Nat. Rys. Co.* and the *Netherlands Railways* do not specify the process of manufacture of the metal, but in point of fact normally use only rails of Thomas steel.

The *Belgian Nat. Rys. Co.* specifies a minimum tensile of 68 to 78 kgr. (43.2 to 49.5 Engl. tons per sq. in.), without any special clauses concerning the chemical composition, except a minimum content of 0.12 % silicon, this constituent being considered efficacious as an active deoxygenating agent.

The *Netherlands Railways* require a minimum tensile of 65 kgr. (41.3 Engl. tons per sq. in.) with a maximum phosphorus content of 0.10 %, and sulphur content of 0.06 %.

The *Dutch Indies Railways* do not define in any precise manner the manufacturing process but only prescribe that the steel shall be basic or acid with the following maximum percentages :

| | |
|---|---|
| Carbon . . . . . | 0.55 % |
| Sulphur . . . . . | 0.06 % |
| Phosphorus . . . . | 0.10 % |

The *Danish State Railways* specify that the rails shall be made from Thomas,

TABLE 6.

## Rail manufacture.

= final rolling temperature; R = breaking load; E = elongation.

| ADMINISTRATIONS. | Manufacturing process of the metal. | Precautions required by the specifications. | | Mechanical requirements of the specifications. | | | Chemical composition, %. | | | | | Manufacturing tolerances allowed by the specifications. | | | Miscellaneous; period of guarantee. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Refining and rolling. | Discard. | Tensile strength, kgr. per mm². | Elongation % | Other requirements. | C. | Mn. | Si. | P. | S. | Length, in mm. | Sectional dimensions, in mm. | Weight, %. | |
| *Deutsche Reichsbahn* | Thomas Siemens-Martin. | ... | ... | T ⩾ 70 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| *Austrian Federal Rys.* | Siemens-Martin. | ... | ... | T ⩾ 65 | ... | ... | 0.55 to 0.65 | 0.8 to 1.4 | ... | ... | ... | ... | ... | — | ... |
| [illegible] | Not specified. Usual process: Thomas. | Initial section of ingot not to be less than 20 times the rail section. *l* = as low as possible. | Before rolling, blooms must be sufficiently sound for rails to be free from shrinkage holes, segregation or inclusions. Top discard may not be less than 25 %. | T = 68 to 78 | A = > 12 % | ... | 0.41 to 0.43 | 0.9 to 1.00 | 0.12 min. to 0.20 | 0.035 to 0.07 | 0.03 to 0.05 | > 6 m. to 18 m. ± 2 mm. > 18 m. ± 3 mm. | Width of foot ± 1 mm. height, width of head and thickness of web: ± 0.5 mm. opening of fishing surfaces + 0 / − 0.5 mm | None. The rails within tolerance taken as weighing 50 kgr. | No guarantee specified. |
| | | | | | | | (Analysis not specified except for Si.) | | | | | | | | |
| *Danish State Rys.* | Thomas. Bessemer. Siemens-Martin. | ... | Such that unsound portions be completely eliminated. | T = 70 to 80 | For R = 70 E = > 12 % | T + 5E ⩾ 130 | ... | ... | ... | ⩽ 0.075 | ... | ... | Width of foot ± 1 mm.: ± 0.5 mm. on height, width of head and thickness of web. | [illegible] | Guarantee specified runs from January 1st following completion of supply. |
| *Netherlands Rys.* | Thomas. | ... | ... | T ⩾ 65 | E ⩾ 12 % | ... | ... | ... | ... | ⩽ 0.10 | ⩽ 0.06 | ... | ... | ... | ... |
| *State Rys. in the Dutch Indies.* | Thomas or Bessemer or Siemens-Martin. | ... | Such that unsound portions be completely eliminated. | T = 60 to 70 | ... | T × E ⩾ 900 | ⩽ 0.55 | ... | ... | ⩽ 0.10 | ⩽ 0.06 | ... | ... | ... | 5 years from the end of year of supply. |
| *Hungarian State Rys.* | Siemens-Martin. | ... | ... | T = 70 to 85 | ... | T + 3E ⩾ 103 | 0.6 to 0.7 | About 0.8 | About 0.2 | About 0.04 | ... | ... | ... | ... | ... |
| *Swedish State Rys.* | Thomas. Siemens-Martin. Ordinary electric. Electric Mn. | ... | ... | T ⩾ 75<br>T ⩾ 80<br>T ⩾ 80<br>T ⩾ 85 | ... | ... | 0.45 to 0.55<br>0.55 to 0.65<br>0.58 to 0.68<br>0.52 to 0.58 | 0.9 to 1.10<br>0.9 to 1.10<br>0.9 to 1.10<br>1.60 to 1.90 | 0.15 to 0.30<br>0.15 to 0.30<br>0.15 to 0.30<br>0.15 to 0.30 | ⩽ 0.075<br>⩽ 0.05<br>⩽ 0.04<br>⩽ 0.04 | ⩽ 0.06<br>⩽ 0.08<br>⩽ 0.04<br>⩽ 0.04 | ± 3 mm. | Width of rail foot − 1 mm.: ± 0.5 mm. on height and width of head and thickness of web. | − 2 % — 1 %. Excess not paid for. Insufficiency deducted. | 5 years from date of supply. |
| *Union of Swedish Private Rys.* | This system applies the specifications of the Swedish State Rys. | | | | | | | | | | | | | | |
| *Bergslagen Ry. (Sweden)* | This system applies the specifications of the Swedish State Rys. | | | | | | | | | | | | | | |
| *Swiss Federal Rys.* | To manufacturer's discretion. | Section of ingots at least 20 times that of finished rails. | The metal must be compact, free from impurities and blow-holes. | T ⩾ 70 | ... | T × E ⩾ 900 | 0.3 to 0.45 | 0.9 to 1.05 | ⩽ 0.15 | ⩽ 0.08 | ⩽ 0.05 | ± 2 mm. up to 8 m. ± 3 mm. over 8 m. | ± 0.2 mm. on height: ± 1 mm. on foot: ± 0.5 mm. on other dimensions. | Up to 2 %. Excess allowed for: 1 % only. | 5 years. |
| *Berne-Loetschberg-Simplon Rys.* | 1) Not specified. Electric Mn. steel. | ... | ... | ... | ... | ... | 0.3 to 0.45<br>0.5 to 0.65 | 0.9 to 1.05<br>1.7 to 1.9 | ⩽ 0.15<br>⩽ 0.35 | ⩽ 0.08<br>⩽ 0.02 | ⩽ 0.05<br>⩽ 0.02 | ... | ... | Up to 2 % + of specified weight. | 5 years. |
| *Polish State Rys.* | Not specified. | Largest possible section of ingot, at least two 18-m. lengths. | Such that unsound portions be completely eliminated. | ... | ... | ... | ... | ... | ... | ⩽ 0.06 | ⩽ 0.05 | ± 2 mm. up to 10 m. ± 3 mm. from 10 to 18 m. | ± 0.5 mm. on height and width of head. ± 1 mm. on foot (width). + 0.75 to — 0.3 mm. on thickness of web. Opening of fishing surfaces: 0.25 mm. | Up to 2 1/2 %: specific weight 7.83. Excess allowed for: only 1 %. | 5 years. |

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Bessemer or Siemens-Martin steel with a maximum phosphorus content of 0.075 %.

The different *Swedish* Systems (*State Railways, Union of Private Railways, Bergslagen Railway*) use, according to the hardness desired, either Thomas or Siemens-Martin steel, or again ordinary or manganese electric steel.

The strength and chemical composition of these four varieties of steel as given in the *Swedish State Railways'* official specifications are as follows :

| | *Thomas steel.* R ⩾ 75 kgr./mm² *(47.6 Engl. t. p. sq. in.)* | *Siemens-Martin steel.* R ⩾ 80 kgr./mm² *(50.8 Engl. t. p. sq. in.)* | *Electric steel* | |
|---|---|---|---|---|
| | | | *ordinary.* R ⩾ 80 kgr./mm² *(50.8 Engl. t. p. sq. in.)* | *manganese.* R ⩾ 85 kgr./mm² *(54 Engl. t. p. sq. in.)* |
| Carbon | 0.45 to 0.55 % | 0.55 to 0.65 % | 0.58 to 0.68 % | 0.52 to 0.58 % |
| Silicon | 0.15 to 0.30 % | 0.15 to 0.30 % | 0.15 to 0.30 % | 0.15 to 0.30 % |
| Manganese | 0.9 to 1.10 % | 0.9 to 1.10 % | 0.9 to 1.10 % | 1.6 to 1.9 % |
| Phosphorus | ⩽ 0.075 % | ⩽ 0.050 % | ⩽ 0.040 % | ⩽ 0.040 % |
| Sulphur | ⩽ 0.060 % | ⩽ 0.060 % | ⩽ 0.040 % | ⩽ 0.040 % |

The *Swiss Federal Railways* do not specify the process of manufacture of rail steel, but lay down the following chemical compositon which may be obtained by the various processes :

| | |
|---|---|
| Sulphur | 0.05 % |
| Phosphorus | 0.08 % |
| Carbon | 0.3 to 0.45 % |
| Manganese | 0.9 to 1.05 % |
| Silicon | 0.15 % |

The breaking strength must be at least 70 kgr. (47.6 Engl. tons per sq. in.)

The *Berne-Lötschberg-Simplon* Railways use the same quality of rails as the Swiss Federal Railways, but also use harder rails of electric steel containing manganese to the following analysis :

| | |
|---|---|
| Sulphur | 0.02 % |
| Phosphorus | 0.02 % |
| Carbon | 0.5 to 0.65 % |
| Manganese | 1.7 to 1.9 % |
| Silicon | 0.35 % |

Finally the *Polish State Railways* leave the process of manufacture to the choice of the manufacturer, whilst limiting the sulphur content to 0.05 %, and the phosphorus to 0.06 %, provided that the rails pass the other specified tests.

As regards the rolling of the rails, the *Belgian Nat. Rys. Co.* and the *Swiss Federal Railways* require that the section of the ingot shall be at least twenty times greater than that of the rail to be rolled from it.

The *Polish Railways* require the section of the ingots to be as large as possible and to produce at least two rails 18 m. (59′ 5/8″) long.

In addition, the *Belgian Nat. Rys. Co.* prescribes that the final rolling temperature shall be as low as possible.

As regards the discard, the administrations require that the unsound parts of the ingot be removed. In this connection, the *Belgian Nat. Rys. Co.* stipulates that before rolling the blooms ought to be sufficiently cropped at the top and bottom to ensure the rails being free from blowholes, segregations or inclusions of whatever kind. The discard from the top of the ingots must not be less than 25 % of their weight.

The macrographical tests and the inspection of the fracture of the top dis-

card are used to check these requirements.

Generally speaking, the replies received show that the breaking strength specified for rails in the running lines varies between 65 and 85 kgr. (47.3 and 54 Engl. tons per sq. in.), the latter value being laid down by the *Hungarian State Railways*.

The ordinary carbon or special manganese electric steels are utilised principally for hard rails of a tensile strength exceeding 80 kgr. (50.8 Engl. tons per sq. in.), which are being experimented with to obtain greater resistance to wear without marked brittleness.

As regards the chemical composition, certain Railways, notably the *Swedish State* and the *Swiss Federal*, indicate the allowable proportions of the various constituents and specify at the same time the minimum breaking stress; others content themselves with stating the breaking stress whilst merely limiting the percentages of sulphur and phosphorus, leaving to the manufacturers complete liberty to adopt the composition which they consider the most suitable to fulfil the specified conditions.

It is a somewhat difficult matter to arrive at average figures for the principal elements composing the various steels.

For Thomas steels, it would not appear desirable to exceed a carbon content of 0.5 %, since brittleness can result from higher proportions.

For Siemens-Martin and electric steels, with which a greater hardness is desired the proportions of carbon may vary between 0.6 and 0.7 %.

The proportions of manganese are generally comprised between 0.8 and 1.0 %.

Silicon is usually present in proportions ranging between 0.1 and 0.2 %.

Phosphorus does not as a rule exceed 0.07 % in Thomas steels and 0.04 % for Siemens-Martin and electric steels.

The proportions of sulphur in Thomas steels does not generally exceed 0.05 % and 0.04 % in Siemens-Martin and electric steels.

The proportions of phosphorus and sulphur may be even less than 0.02 % for the more carefully produced metals.

*Inspection of rails.*

The replies, tendered by the administrations consulted, to the second question asking what are the conditions stipulated for the acceptance of rails are classified in Table 7 attached hereto.

The methods most commonly adopted for ensuring good quality of the metal from which the rails are made generally include :

— a partial or complete chemical analysis.

All those Railways which have sent copies of their specifications require partial or complete chemical analyses, from the manufacturer. A certain number of checks on analyses, by the Administrations, are provided for.

— a test of the homogeneity of the metal, either by simple examination of the broken sections, or by a macrographical investigation.

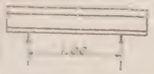
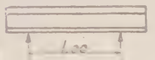
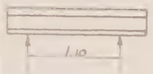
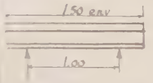
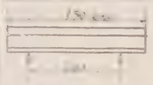
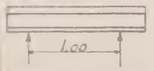
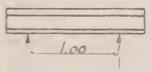
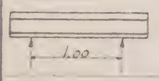
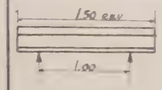
On the *Belgian Nat. Rys. Co.* the texture is examined, and since 1923 the macrographical examination is used as rejection test. With this object, examples of good and bad macrographs have been published as a guide to the manufacturers.

The *Netherlands* and the *Polish State Railways* likewise require macrographical tests, but only for information.

Micrographical tests are regularly carried out by the Belgian Nat. Rys. Co. on sections of rails taken from the top discards, in order to verify the degree of homogeneity of the metal and to make sure some « overheated » structures do not reveal that the rails have been rolled too hot.

The *Polish State Railways* also regularly carry out micrographical examina-

TABLE 7. — **Rail acceptance tests.**

| ADMINISTRATIONS. | Drop tests. | Hardness tests. | Tensile tests. T = tensile strength. E = Elongation. | Other mechanical tests. | Macrographical or micrographical tests. | Chemical analysis. |
|---|---|---|---|---|---|---|
| *Deutsche Reichsbahn* |  5 000 kgrm. Deflection 100 mm. for a distance between supports of 1 m. | ... | T ⩾ 70 kgr./mm². | ... | | |
| *Austrian Federal Rys.* |  Initial blow (kgrm.) = $\frac{J}{\rho^2}$. J = moment of inertia of the rail about centre of gravity in cm⁴. ρ = distance from the centre of gravity to the most stressed fibres. Succeeding blows = $0.4 \frac{J}{\rho^2}$ up to $f = \frac{60}{e}$. | Hardness tests. | Test piece of 20 mm. diam. and 200 mm. effective length. T ⩾ 65 kgr./mm². | | | |
| *Belgian National Rys. Co.* |  6 000 kgrm. The drop of the tup is 6 m. The weight of the tup is 1 000 kgr. After each blow the deflection is recorded. All discards must resist one blow without breaking. | Brinell hardness tests on sections from the top discard. Two impressions which must have a diameter varying between 3.9 and 4.45 mm. | Test piece of 13.8 mm. diam.; 100 mm. between gauge marks. T = 68 to 78 kgr./mm². | Resilience tests with the *Charpy* pendulum. 3 tests pieces of the same series must give a resilience not less than 2 kgrm./cm². *Texture:* Sections taken from the foot by means of a chisel. The breaks must exhibit a fine close-grained texture. | Macrographs made by the *Baumann* method on a number of sections representing 12 % of the number of ingots: must not show any appreciable segregation. Micrographs at different places must not show any signs of overheating. | The works must supply, before the start of the tests, complete analyses of all the casts. These analyses furnish the amounts of C, Mn, S, P and Si, the minimum content of which, 0.12 is essential. Analyses are controlled by check tests in the laboratories of the Company. |
| *Danish State Rys.* |  For a 37-kgr./m. rail: 5 000 kgrm. } Weight of tup For a 45-kgr./m. rail: 6 000 kgrm. } 1 000 kgr. Pieces of rail cut from the top end of the bar before the first rail. During the test the specimen ought to have a temperature of from 15 to 50° C. Must resist two tests without showing any sign of fracture. | Ball of 19 mm. Under pressure of 50 000 kgr. the impression ought not to be less than 3.5 mm. nor greater than 5 mm. in depth. | Test piece of 20 mm. diam. and 200 mm. effective length. T = 70 to 80 kgr./mm². One test per 100 tons of rails. | ... | ... | The works must supply the analyses for S and P of all the casts and a complete analysis as called for by the inspector. |
| *Netherlands Rys.* |  Weight of the tup = 1 000 kgr. The energy of the first blow is to be 4 500 kgrm. for 46.900-kgr. per m. rails. After the first blow the test is to be continued with a blow of 2 250 kgrm. until the deflection reaches 100 mm. without fracture of the rail. | ... | T ⩾ 65 kgr./mm². | ... | ... | |
| *State Rys. in the Dutch Indies* | Impact tests. | ... | T = 60 to 70 kgr./mm². | ... | Macrographical tests. | The works must supply the analysis for C and P of all the casts and one complete analysis for every 10 casts. If the inspector considers it desirable, checks on the analyses are made in the laboratory of the Company. |
| *Hungarian State Rys.* |  Weight of the tup = 500 kgr. Repeated blows until the rail has reached the stipulated deflection without fracture. This deflection is 91, 84, 82 mm. for the 44.5 kgr. m. rail, according to hardnesses of 70-75, 75-80, 80-85 kgr./mm² and 86, 80, 78 mm. for the 48.3-kgr./m. rail. Drop of tup: 3 blows from a height of 6.30 m. and consecutive blows from 3.15 m. for the 44.5-kgr./m. rail. 3 blows of 7.00 m. and consecutive blows of 3.50 m. for the 48.5-kgr./m. rail. | Brinell tests for information purposes. | T + 3E = 103. | Wear tests by the *Spindel* system, for information purposes. | ... | |
| *Swedish State Rys.* |  40-kgr. rail: 6 000 kgrm. } Weight of tup: 1 000 kgr. 30-kgr. rail: 4 000 kgrm. } Pieces of rail cut from the top end of the bar before the first rail. During the test the specimen ought to have a temperature of from 15 to 50° C. No trace of fracture or other defect after the test. | Ball: 19 mm. diam. Load of 50 000 kgr. Depth of impression ought to have maximum values of: 3.8 mm. for *Thomas*: 3.4 mm. for Siemens-Martin; 3.4 mm. for ordinary electric steel: 3.1 mm. for electric manganese steel. | For Thomas, T ⩾ 75 kgr. For Siemens-Martin, T ⩾ 80 kgr. For ordinary electric steel, T ⩾ 90 kgr. For electric manganese steel, T ⩾ 85 kgr. for informative purposes. | ... | ... | The maker must place at the disposal of the inspector the analyses of samples, made by him. Basic process: Chemical analysis for C and P, for all the casts. Complete analysis of 1/10 of all the casts if the inspector requires it. *Acid process:* Analyses so far as required by the Inspector. |
| *Union of Swedish Private Rys.* | This railway applies the specifications of the Swedish State Railways. | | | | | |
| *Bergslagen Ry. (Sweden)* | This railway applies the specifications of the Swedish State Railways. | | | | | |
| *Swiss Federal Rys.* |  Temperature of the rail + 10° C. minimum. Initial blow 3 000 kgrm., followed by successive blows of 1 200 kgrm. until the deflection reaches 100 mm. without breaking or cracking. | Ball of 19 mm. diam. Load of 50 000 kgr. The impressions obtained ought not to exceed 4.35 mm. in depth and 16 mm. in diam. | Test pieces of 20 mm. diam. and 200 mm. effective length, cut from the head of the rail. T ⩾ 70 kgr./mm². | Resilience 2 kgrm./cm², if possible. | ... | The works supply complete analyses of all the casts. The checking of the analyses is made upon chips taken from the test pieces. |
| *Berne-Loetschberg-Simplon Rys.* | ... | ... | ... | ... | ... | ... |
| *Polish State Rys.* |  Weight of tup = 1 000 kgr. Must resist two blows from 1 000 kgr. falling from a height, expressed in metres, equal to 1/10 of the weight per metre of the rail, expressed in kgr. After the second blow, the rail may have any deflection whatever, but must not be broken. | Brinell tests. Diameter of ball 10 mm.; pressure 3 000 kgr.; ratio of the pressure to the impressed area ⩾ 200 kgr. per mm². | Tensile tests. (for information purposes). | ... | Macrographical test on a complete transverse section of test piece, 30 mm. thickness, cut from the end of the rail. Micrographical test on the { head. web. foot. | The works must furnish the analyses of all the casts. The analyses give the content in C, Mn, Si, P, and S. The samples are taken at the time of pouring, and are checked by the inspector once monthly in the course of manufacture. |

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tions on the head, web, and foot of short lengths of rail cut off during manufacture.

— tensile tests, which are rejection tests on all the railways, except the Polish State which regards the tensile tests as only being carried out as a matter of information.

These tests performed on test pieces machined from the rail give the breaking stress, the elongation, and if desired, the elastic limit of the metal.

— brittleness tests, which consist either of measuring the live load absorbed by small test pieces taken from the body of the rail, or more frequently of submitting short lengths of rail to drop tests, which they must stand according to the specifications.

The drop test on rails as an eliminating test is specified by all the Railways which we have consulted, whilst resilience tests on small test pieces are made only by the *Belgian Nat. Rys. Co.* and the *Swiss Federal Railways.*

— hardness tests, which amplify and check the tensile tests and give an idea of the resistance of the rails to wear.

In this connection, the Belgian Nat. Rys. Co. requires that rails subjected to the Brinell hardness test with a ball of 10 mm. (4″) under a load of 3 000 kgr. (6 600 lb.) should give impressions of 3.9 to 4.45 mm. (0.153′ to 0.175′) diameter.

The *Hungarian State Railways* are the only ones to include a wear test in the specifications.

The *Belgian Nat. Rys. Co.* has recently revised the technical clauses of its specifications for ordinary rails and has reduced appreciably the number of static tests (tensile) in order to give greater importance to the dynamic tests. Thus, the number of resilience tests on small specimens taken from the head, the web and the foot of the rails has been increased, and the drop test with a 1 000-kgr. (2 200 lb.) tup falling 6 m. (19′ 8 1/4″) has been standardised for all top discards from all the ingots.

In short the above remarks show that the aim of the most recent specifications of the main-line Railways has been above all to secure rails of sound metal, of a compact and homogeneous texture capable of better resistance, without abnormal breakages or premature damage, to the various stresses resulting from the severity of present-day operating conditions.

*Use of special steels.*

In certain cases it has appeared more economical to use special steels. The replies to the first question already show that several Railways use more or less extensively rails from hard Siemens-Martin or electric steels, with a high carbon content, and a breaking strength exceeding 80 kgr./mm² (50.8 Engl. tons per sq. in.)

Tests are in hand also by the Belgian Nat. Rys. Co. of rails made from electric steel for use on curves of less than 500 m. (25 chains) radius in order to reduce the side wear.

Hard electric perlitic steels having a manganese content of 1.6 to 1.9 % are mentioned by several Administrations, namely the *Austrian Federal* and the *Swedish State Railways.* With the same object, the *Deutsche Reichsbahn* makes use of compound rails, the head being of very hard steel and the web and foot of ordinary steel.

The *Danish* and *Hungarian State Railways* also refer to the use of this kind of rail as an experiment.

In tunnels, to reduce oxidation, the *Belgian Nat. Rys. Co.* is experimenting with small quantities of rails of Thomas and electric steel having a copper content of 0.4 to 0.6 %.

*Heat treatment of rails.*

In recent years, heat treatment of rails as a means of improving the characteristics of the ordinary rail metal, seem to have met with favour on several Railways.

This heat treatment is usually effected by hardening the head of the rail in water, immediately after leaving the rolling mill, or after cooling the rails and reheating to the required temperature, the tempering being obtained by conduction of the heat stored in the mass of the head.

According to the degree of hardening and the efficacy of the subsequent tempering, the structure of the outer skin of the head becomes either martensitic or sorbitic, which finally governs the quality of the whole rail.

The *Deutsche Reichsbahn* uses rails similarly treated.

The *Belgian Nat. Rys. Co.* and the *Hungarian State Railways* are conducting tests with rails of a similar kind.

The former Railway has adopted the practice, since 1932, of putting into service, on curves of less than 500 m. (25 chains) radius, small quantities of rails treated by the process of the « Société Minière et Métallurgique de Rodange-Ougrée », which differs from the current practice of the other systems by the rails being completely cooled after rolling and then reheated in a suitable furnace prior to hardening the head.

This method possesses the obvious advantage of hardening the head of the rail at the correct temperature, and at the same time obtaining an annealing effect in the remainder of the section.

It is clear, of course, that the cost with this process is appreciably larger than that with the direct hardening method and the respective merits of each system will have to be judged by the practical results obtained.

These methods of treatment will, of course, be adopted much more extensively in the future if they favourably affect the economic balance sheet of the track.

* * *

In order to reduce the drawbacks of the present type of rail joint, the Belgian Nat. Rys. have had unter test, since 1933, rails with the ends heat-treated by means of the « Arbed » system. Up to date about 6 000 rails 27 m. (88′ 7″) long have been placed in service in the fast lines, after having received this treatment which hardens the rolling surface of the rail ends and the upper and lower fishing surfaces, by improving the structure of the metal over the whole rail section, including the web in line with the fish bolt holes.

The object in view is to reduce the number of breakages at the ends by avoiding crushing and unevenness at the joints, to obtain harder fishing surfaces with greater resistance to hammering where in contact with the fish-plates, and finally to overcome the tendency of the rails to develop fissures in the bolt holes.

We are able to state that up to the present joints of rails treated in the above manner behave definitely better than ordinary rails of the same age and stressed under identical conditions.

* * *

### b) The section and length of rails for main-lines.

The information received from the Administrations consulted is summarized in Table 8.

*Rolling section and weight of the rails.* — With the exception of the *Berne-Lötschberg-Simplon* which still puts into service new bull-headed rails at the same time as flat-bottomed rails, all the Administrations consulted have adopted the Vignole rail.

The weight per linear metre of the rails used on the main lines is usually between 42.5 kgr./m. (83.2 lb. p. yd.) (Poland) and 50 kgr. (100.8 lb. p. yd.) (Belgium). A marked tendency is noticed towards increasing the number of sleepers, to a much greater extent than increasing the cross section of the rail. The standard 50-kgr/m. rail of the *Belgian Nat. Rys.*

TABLE 8.

## Section and length of rails laid on the main lines.

| ADMINISTRATIONS. | Section of rails. V = Vignole (flat-footed). DH = Double headed. | | Dimensions (in mm.). | | | | Usual length laid. | | Welding. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Description. | Weight, kgr. per linear metre. | *a* | *b* | *c* | *d* | New rails. | Re-used rails. | When used. | Lengths obtained and proposed. | Process used. |
| *Deutsche Reichsbahn.* . | V | 49 kgr. | 65.2/70 | 14 | 125 | 148 | 30 m. | ... | Long welded rails on bridges and in tunnels. | In the open road 60 m., as an experiment. | Thermit and electric resistance welding. |
| *Austrian Federal Rys.* . | V | 49 kgr. | 67 | 14 | 125 | 148 | 25 m. | In sidings, cut and resistance welded end to end up to 56 m. length. | On large bridges having expansion devices, the length may reach 145 m., in the tunnels 100 m. | 30 m. | Resistance welding, exceptionally thermit. On the site, for bridges of considerable length. |
| *Belgian National Rys. Co.* | V | 50 kgr. | 72 | 15 | 140 | 151 | 27 m. | 35 m. | Tunnels and bridges: 54 m., sometimes 108 m. | In the open road, 54 m. as a trial on the Brussels-Antwerp electrified line. | Electric resistance welding, for rails of 54 m. and less. In tunnels and on bridges, rails of 54 m. welded in pairs by the thermit process. |
| *Danish State Rys.* . . | V | 45 kgr. | 68/70 | 13.76 | 126 | 140 | 15 and 30 m. | ... | Long welded rails on bridges and in tunnels. (1 300 m.). | For 45-kgr./m. rails. 30-m. lengths formed by welding together 2 lengths of 15 m. | Thermit process. |
| *Netherlands Rys.* . . . | V | 46.9 kgr. | 72/74 | 14 | 120 | 142 | 18 m. | ... | Original rails ± 36 m. On the large bridges the welded length may reach ± 200 m. with expansion devices. | As a trial, 24 m., which gives satisfaction. | Thermit process. |
| *State Rys. in the Dutch Indies* . . . . . | V | 41.52 kgr. | 68/71 | 13.5 | 110 | 138 | 13.60 m. | ... | ... | 27.20 m. by electric resistance welding. | Resistance welding. On a few bridges, electric arc welding. |
| *Hungarian State Rys.* . | V<br>V<br>V | 42.8 kgr.<br>44.3 kgr.<br>48.3 kgr. | 70<br>66/70<br>65/70 | 15<br>14<br>15 | 120<br>120<br>120 | 139<br>140<br>148 | 24 m. | ... | On large bridges and in tunnels, the length of the welded rails is determined by local conditions. | 30 m. | Thermit welding, trials with arc and oxy-acetylene welding. |
| *Swedish State Rys.* . . | V | 43.2 kgr. | 69/70 | 14 | 133 | 133 | 20 m. | ... | ... | 18.40 m. and 22.40 m. | Resistance welding. |
| *Union of Swedish Private Rys.* . . . . . | V<br>V | 40.5-41.18 kgr.<br>43.5-43.86 kgr. | State Railways' 1896 type.<br>Prussian type. | | | | 15 m.<br>in all cases. | ... | ... | 20 m. by machining. Welding of old rails: 45 m. (3×15). Welding of new rails: 40 m. (2×20). | Thermit process. |
| *Bergslagen Ry. (Sweden)* . . . . . | V<br>V | 43.8 kgr.<br>45.5 kgr. | 65<br>67/69 | 14<br>14 | 125<br>125 | 140<br>142 | 20 m. | ... | ... | 40 m. by welding. | Butt welding (electric arc). |
| *Swiss Federal Rys.* . . | V | 45.93 kgr. | 65 | 14 | 125 | 145 | 24 m.<br>Exceptionally 30 m. on bridges and at level crossings. | ... | ... | 33 m. in the open. 72 m. in tunnels (by welding rails either in or out of the track). | Electric resistance and thermit welding. Trials by the electric arc and oxy-acetylene methods. |
| *Berne-Loetschberg-Simplon Rys.* | V<br>V<br>D-H | 45.93 kgr.<br>48.85 kgr.<br>42 kgr.* | S.F.Rys. I.<br>S.F.Rys. II.<br>S.O. type. | | | | 24 m. | ... | ... | None. | None. |
| *Polish State Rys.* . . . | V | 42.5 kgr. | 68/70.2 | 13 | 125 | 140 | 18 m. | ... | ... | It is intended to increase the lengths of the rails by welding. | ... |

*Co.* has replaced, for relaying purposes, the light rail weighing 40.65 kgr./m. (81.9 lb. p. yd.) and the heavy 52 and 57 kgr./m. (104.8 and 114.9 lb. p. yd.) rails; the sleepering alone differs, according to the speed and the traffic. Track equipped with 50-kgr./m. rails having a wide foot (140 mm. = 5 1/2″) does not cost more than track with 40.650 kgr./m. narrow-footed (105 mm. = 4 1/8″) rails because the latter requires metal bearing plates. There are, moreover many well known advantages in using a standard rail section.

*Length of rails.* — The new rails at present used in the main lines vary from 13.60 to 30 m. (44′ 7 7/16″ to 98′ 5 1/8″) in length.

The *Deutsche Reichsbahn* regularly uses in the open track 30-m. rails and the *Belgian Nat. Rys. Co.* uses exclusively 27-m. (88′ 7″) rails on main lines.

The Belgian Nat. Rys. utilise on branch lines carrying light traffic (under 8 000 tons daily) serviceable rails taken up from the main lines, worn down less than 5 mm. (3/16″), with the ends cut off, and if need be, with the section of the head improved. Rails thus repaired are welded electrically, in a workshop, by the flash-butt method, into standard lengths of 35 m. (114′ 10″).

*Welding.* — Most of the Administrations consulted resort to welding to increase the length of the rails. This practice was first of all adopted in sidings. In the running road, it has been applied chiefly in tunnels and on metal bridges.

Experiments made show that except at the ends, the track can be made continuous in tunnels where the temperature variation is small. In Denmark a section of track 1 300 m. (4264′) long has been welded in a tunnel 1 500 m. (4920′) long.

Several railways, namely those in Germany, Austria and Holland, weld the joints on metal bridges. Holland gives 200 m. (656′) as the maximum length of rails welded into a single length. Austria has not exceeded 145 m. (457′ 8″) in length and Belgium 108 m. (354′ 4″).

It is well understood that special devices to take up expansion are provided in the track at suitable locations. But the problem occupying many of the railways at the present time is that of laying such long rails in the running roads. Germany has already for a number of years laid on the main lines 60-m. (197′) rails. The joint gaps are sensibly less than those obtained by calculations based on the free expansion of the rail for the maximum range of temperatures which might occur in the course of the year.

In any case, however the track be laid, the expansion is more or less opposed by the tightness of the fastenings of the rails to the sleepers, by the grip of the fishplates and by the ballast. Variations in temperature always develop stresses of greater or lesser amplitude in the rails, sometimes in compression and sometimes in tension. These stresses are a function of the more or less considerable resistance offered by the fastenings to the rails sliding on the sleepers and when the resistance of the fastenings is very great, as for example, when the rails are fixed to the sleepers by clips and bolts or by cotters, owing to the resistance exerted by the ballast against the track sliding.

The variation in stress, when expansion or contraction is entirely prevented, is roughly 0.250 kgr./mm$^2$ of the cross section of a rail for each degree C. of change in temperature of the rail (0.35 Engl. ton per sq. in. per degree F.); the variation in load over the entire section of a rail having a weight of 50 kgr. per metre (100.8 lb. per yd.), under the same conditions, is approximately 1 600 kgr. (3 520 lb.).

In order to determine approximately the resistance offered by the ballast to the longitudinal sliding of the track, the following test has been made at the central permanent way depot of the Belgian Nat. Rys. Co.

A section of track, composed of two rails 6 m. (19′ 8 1/4″) long, laid on ten timber sleepers was prepared. The standard ballast consisted of broken stone, 40 to 60 mm. (1 9/16″ to 2 3/8″); the thickness of the first layer, under the sleepers, was 30 cm. (1′); the second layer, between the sleepers, was trimmed off to the level of the tops of the sleepers.

After packing the ballast, the longitudinal displacement of the track carrying no load was determined by the aid of a hydraulic jack thrusting, on the one hand, against a fixed stop and on the other hand against the centre of one of the end sleepers of the section of track.

The initial sliding began under a mean thrust of 3 400 kgr. (7 500 lb.), being about 570 kgr. per metre (983 lb. per ft.) of track.

In the course of the experiments there was no evidence of the rails sliding relatively to the sleepers.

This result fairly agrees with that obtained by Mr. Felice CORINI, Professor at the Higher Royal Institute of Engineers, at Genoa, viz. — 600 kgr./m. (403 lb. per ft.) of track (1).

Tests made on the fastenings of the rails to the sleepers have given, as was to be expected, results which depend upon the type of fastening and the degree of tightening. Under normal conditons of tightening, the values of the resistance to sliding between rails and sleepers in the case of fastening by clips, bolts and spring washers, or cotter fastening, were appreciably greater than that of the longitudinal sliding of the whole of the track on the ballast. The track (rails and supports) as a whole therefore moves longitudinally, when the above-mentioned fastenings are properly tightened.

Tests have also been made on the new track of the Brussels-Antwerp electric line, consisting of rails 54 m. (177′ 2″) long, laid upon 98 sleepers per rail. The hard-wood sleepers are protected by ribbed sole plates fixed to the sleepers by means of 2 coach screws. The rails are secured to the base plates by means of clips and bolts, with spring washers interposed, having a resistance to flattening of 3 tons.

Prior to the tests, the rail fastenings and fish bolts were unscrewed at night time, at a temperature round about 9° C. (48° F.) with the object of eliminating stresses produced by temperature variations, and they were then tightened up again.

Recording instruments with amplifying hands, placed at regular intervals at the ends, in the middle and intermediately, half-way between the ends and the centre of each of the rails under observation, measured the expansion of the track relatively to fixed pegs in the ballast and independant of the track.

Observations were made on a section of track 54 m. (177′ 2″) long; on another section of 162 m. (531′ 6″) with closed joints, and on a further section of 270 m. (885′ 10″) likewise with closed joints. The fish-plates at the ends of the sections under observation were slackened so as to have widely opened joints.

The results of these observations are given in the diagrams, figures 1 to 3.

The observations were made between 9 and 33.5° C. (48.2 and 92.3° F.).

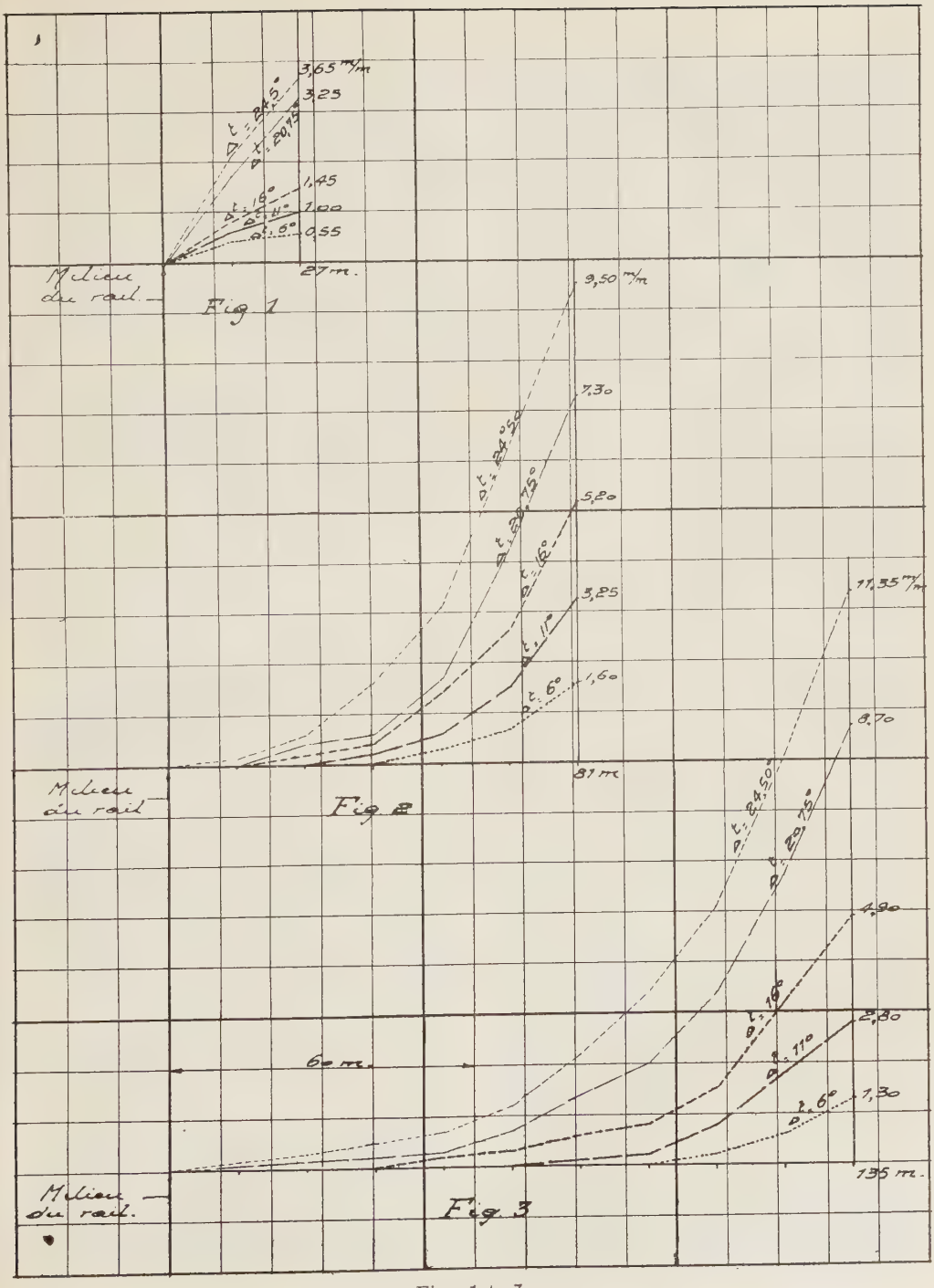
The displacements occurred on both sides of the centre of the lengths tested and they were roughly symmetrical. The diagrams give the results measured at 15°, 20°, 25°, 29.75° and 33.5° C. (59, 63, 77, 85.5 and 92.3° F.).

They show that for a variation in temperature from 9° C. to 33.5° C. making 24.5° C. (44.1° F.) difference, the extremities of the 270-m. (885′ 10″) section of track were displaced by 11.35 mm. (0.445″). Calculation gives, on the assumption of free expansion of the rails, a displacement of the ends, relatively to the centre of the 270-m. section, equal to :

$$\frac{1}{80\,000} \times 135\,000 \times 24.5 = 41.3 \text{ mm.}$$

$$= (1.626″).$$

(1) *Bulletin of the International Railway Congress Association*, April 1936.




Figs. 1 to 3.

*Note:* Milieu du rail = middle of rail.

The expansion is consequently hampered and stresses increasing towards the middle part are developped in the rail.

The section of rail situated at 60 m. (197′) on either side of the middle of the 270-m. length moved to the extent of only 1 mm. (0.039″), instead of 18.4 mm. (0.72″) if the expansion had been free. Thus it may be said that the expansion of the middle portion of the length is entirely prevented and that there are developed in the rail stresses equal to : 0.250 kgr. × 24.5 = 6.125 kgr. per mm² (3.89 Engl. tons per sq. in.) of cross section.

It should be noted that stresses of this magnitude can develop in rails of any length in traffic when, owing to creep, a certain number of joints are closed up, especially if the track abuts at one end against points and crossings.

Thus arises the idea of welding in situ the joints of all the rails except those in points and crossings.

The precaution would be taken of welding the joints at a temperature of about 30° C. (86° F.) after having practically eliminated stresses by completely separating the rails after slackening the fastenings to the sleepers, and the fishplates.

Assuming that after welding, the maximum temperature reaches 55° C. (131° F.) and the minimum temperature — 10° C. (14° F.), or a range relatively to the temperature of the rail when welded of 25° and 35° C. (45 and 63° F.) respectively, the compression stresses will not exceed 0.250 × 25 = 6.250 kgr./mm² (3.97 Engl. tons per sq. in.) of the rail section, and the tensile stresses will reach a maximum value of 0.250 × 35 = 8.75 kgr./mm² (5.56 Engl. tons per sq. in.) of the rail section.

This solution is perhaps preferable, since it limits the stresses to pre-determined figures.

Joints of long rails always get out of adjustement to a greater or lesser extent. Consequent upon a sudden and material increase in temperature, compression stresses above 6 kgr./mm² (3.81 Engl. tons per sq. in.) of rail section may easily occur.

By welding the rails, wide joints in winter are incidentally avoided, and track maintenance is considerably simplified.

Obviously any lifting of the track when the temperature of the rails exceeds 45° C. (113° F.), which is an exceptional figure, must be prohibited and the layout in plan, whether on the straight or on curves, should be maintained as accurately as possible.

Rail welding over long lengths of track is practised in America, principally on the Delaware & Hudson Railroad (1).

The most commonly employed welding processes are the electric resistance process, and the thermit process. The electric arc and oxyacetylene methods are likewise practised on several systems, generally experimentally.

The *Belgian Nat. Rys. Co.* since 1935 has made more than 20 000 resistance welds by means of an A. E. G. automatic welding plant.

Pieces of welded rail, weighing 50 kgr./m. (100.8 lb. p. yd.) have been subjected to drop, tensile, static bending, resilience and Brinell hardness tests as well as to metallographical examinations.

Compared with the thermit welding and electric welding made with a manually operated machine, the electric process with an automatic machine shows an incontestable superiority, the adjustement of the machine enabling the zone of coarse crystallisation from overheating, which occurs at the weld, to be reduced to the minimum.

Rails 54 m. (177′ 2″) long on the Brussels-Antwerp electrified line, made up of two 27-m. (88′ 7″) lengths welded to-

(1) The present note had been written when there appeared in the *Revue Générale des Chemins de fer* the noteworthy investigation by Mr. A. Martinet, Chief Engineer, Paris-Lyon-Méditerranée Railways, on the « Buckling of jointless track on ballast, and rails of great length » which contributes a theoretical study of the first order to the debate.

gether, have been annealed around the welds, to 875° C. in an oil fired furnace, provided with a self-recording pyrometer.

The overheated zone in the weld exhibiting before annealing a highly developed acicular crystallisation, entirely resumes its normal condition by annealing.

Welded second-hand rails put into service in branch lines and sidings without being annealed have given satisfaction up to the present.

Electrically- and thermit-welded rails unannealed, have been subjected to fatigue tests by repeated bending on a 50-ton Amsler vibrator at 500 vibrations a minute.

All the thermit welds, except one, broke, but none of the electric welds could be broken on this machine.

Additional tests will be made on an Amsler vibrator of 100 tons.

**c) The rules governing the withdrawal of rails and the means employed to delay this withdrawal.**

Particulars given on this subject by the Railways consulted are summarized in Table 9.

In actual practice rails are withdrawn from the main lines long before the limits of wear prescribed by the regulations are reached, for a variety of reasons, such as fracture at the ends starting from the fish bolt holes, deformation of the ends, wear of the fishing surfaces, etc.

The *Belgian Nat. Rys. Co.* has adopted in recent years a policy affecting rail renewals, based on the following considerations :

It has been found from measurements made on the rails of our main lines that the average vertical wear of the rail head is from 0.5 mm. to 0.6 mm. (0.0196″ to 0.0236″) per annum, for a daily traffic of about 50 000 tons.

It is noticed that this wear is not markedly influenced by down (1) or up gradients.

On curves, the distribution of the axle load may be more or less unequal on the two files of rails, such inequality increasing as the radius is smaller and the superelevation large.

Moreover, on curves of small radius the side wear of the rail is considerable.

The rails on curves therefore have to be renewed although the rest are still very good; the curves therefore should be eliminated when considering the frequency of the general renewal of rails. Excessively worn rails in curves should be replaced at the suitable moment by second-hand ones having the same vertical wear as that of the adjacent rails. The proportion of these rails is not very high, being of the order of from 5 to 10 %.

Track laid in tunnels also demands special treatment, since the rails deteriorate more rapidly as a result of the constant dampness and of the action of the fumes which linger there.

The general problem of the frequency of rail renewal on main lines is thus simplified.

The normal replacement of rails, as much on roads carrying heavy traffic as those with light traffic, is not undertaken on account of the diminution in section, but most often on account of the general condition of the permanent way as a whole.

In average cases the vertical wear of the rails in a road which has reached a state justifying replacement is from 5 to 6 mm. (3/16″ to 1/4″). This reduction in height does not affect the strength of the track very much, but usually when the rails are so far worn, the ends are so deformed and the fishing surfaces so worn that the track maintenance becomes very costly and difficult.

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(1) Since the braking of the trains takes place normally on revolving wheels, the action between wheels and rails is as though there were no braking.

If therefore we take 5 to 6 mm. (3/16″ to 1/4″) as being the maximum allowed wear of rails in main lines, such track carrying a daily traffic of 50 000 tons will have to be renewed every 10 years, in view of what has been stated above.

Accepting this assumption, the frequency « $y$ » of renewal of a main line carrying a daily traffic of $x$ tons will be :

$$y = \frac{10 \times 50\,000}{x}$$

The equation $xy = 500\,000$ is that of a rectangular hyperbola plotted on its asymptotes which are perpendicular to each other.

The renewal period of important lines has been reduced to 3/4 of that calculated by the above formula, the practical limit of vertical wear being thus fixed at 4 mm. (5/32″) approximately for these lines.

Such lines carrying many fast trains naturally should be renewed more often than the other lines.

The maximum life of rails in running roads carrying light traffic can be accepted as 50 years.

The average age of rails in all sections of the running roads with a given traffic has been computed. Statistics have been prepared of the traffic density in tons on all sections of the System.

The practical life of the rails on these sections of the running roads has also been calculated in terms of the daily tonnage they carry.

Finally the ratio of the average life to the practical life of the rails for each of these sections has been computed.

For an isolated section, this ratio will be about 0, if the rails of the whole section have just been renewed, or will be equal to 1, if all the rails of the section have reached the practical life, or some value between 0 and 1.

If this ratio or index is greater than unity, the practical life has been exceeded.

The average life, the renewal frequency and the index are determined for all sections of the main lines of the system, and for all the sections of its other lines. Finally the mean index value for the whole of the lines of the system is obtained.

These tables show that the positon is generally favourable, with an average index of 0.36.

This state of affairs is, in part, the consequence of the interruption and postponement of renewals during the war period.

For the aggregate of all the running roads of the *Belgian Nat. Rys. Co.*, the average renewal period is about 37 years, corresponding to a yearly percentage of about 2.75. In order to allow for contingencies 3 % has been assumed.

*Remarks.* — Such calculations are not absolutely correct, the tonnages not always being recorded accurately.

Moreover, the tonnage is supposed constant, although it varies day by day and the traffic currents alter. It is nonetheless an excellent guide to a rational renewal policy. Moreover, the vertical wear of the rails is measured in all cases before the renewal is decided.

Theoretically, three per cent (3 %) of the rails in the running roads should consequently be renewed yearly.

This number does not include track having to be renewed prematurely, when altering the layout of lines and stations, nor curves with heavy side wear, nor again track in tunnels.

Taking these latter sections into account, the average percentage of rail renewal is 4 %.

Rails are removed from important lines when worn 4 mm. (5/32″).

Such rails are used on secondary lines: after cutting off the ends the rails are resistance welded and make very good second-hand rails 35 m. (114′ 10″) long. Rails worn 4 mm. in fact will give 25 years' service (average life of the sleepers) in roads carrying 8 000 tons daily (annual vertical wear 0.08 mm. (0.315″), before the total vertical wear reaches 6 mm. (1/4″).

TABLE 9.

# Rules for removing the rails from the track and building up worn rails.

V = Vertical wear
L = Lateral wear. } beyond which the rails are taken up.

This latter is usually measured 15 mm. below the running surface.

| ADMINISTRATIONS. | Rules for taking up rails on the main lines | | Building up of rails. | REMARKS. |
|---|---|---|---|---|
| | According to vertical and lateral wear of the rail heads. | For other causes: defects, damage. | | |
| *Deutsche Reichsbahn* . . . . . | When the vertical and lateral limits of wear are reached. | When defects, cracks, breaks, etc., are discovered. | Not done. | ... |
| *Austrian Federal Rys.* . . . . . | The rails are replaced when necessary through pronounced wear or other defects. | | Not done. | We usually cut off the ends of removed rails fit for re-use. |
| *Belgian National Rys. Co.* . . . . | V = 4 to 6 mm.<br>L determines the replacement of the rail, when it reaches the lower edge of the head or when the inclination to the vertical is about 30°. | The following defects cause the removal of the rails: cracks, flaking, crushing, corrugations. | Not done. Repair of crossings as an experiment. | Cutting off the ends and resistance welding, for making up long rails, re-used on secondary lines and in sidings. |
| *Danish State Rys.* . . . . . | Rails of 45 kgr./m. and speed $\geqslant$ 70 km./h.: V = 8 mm.<br>Rails of 37 kgr./m.: V = 10 mm.<br>L = 12 mm. measured along a horizontal passing through the centre of the radius forming the inner edge of the head. | Fishings and welded parts (when welding is used) are specially watched. | Not done. | Renewal by complete sections preferred. |
| *Netherlands Rys.* . . . . . | V = 15 mm. L = no fixed limit. | In practice, the limit of wear is never reached in the running roads; removal takes place for defects, corrugation of the running surface, wear of the fishing surfaces, etc. | Not done. | ... |
| *State Rys. in the Dutch Indies.* . . | Moment of vertical resistance is reduced by wear to 75 % of the original moment. | Visible defects. | Not done. | ... |
| *Hungarian State Rys.* . . . . . | No absolute rules. | The extent of the wear, the defects of the running surface, indications of fatigue are taken into consideration having regard to the loads, the speed and safety. | Trials contemplated. | ... |
| *Swedish State Rys.* . . . . . | No rules. According to wear and also other indications. | | Not done. | ... |
| *Union of Swedish Private Rys.* . . | V and L wear from 5 to 8 mm. | Great attention is given to crushing of the ends. | ... | ... |
| *Bergslagen Ry. (Sweden)* . . . . | No special instructions. The rails are withdrawn when crushing at the ends has become excessive or in case of defects. | | ... | ... |
| *Swiss Federal Rys.* . . . . . | V = 14 mm. L determines the replacement of the rail, when the lateral surface is worn along a concave curve the versine of which reaches 1 mm. | Removal is generally carried out as the result of wear and deformation of the running surface at the ends. | Not done. | ... |
| *Berne-Loetschberg-Simplon Rys.* . . | V = 14 mm. L = 9 mm. | Fractures of rails or cracks in the fish-plates. | Not done. | ... |
| *Polish State Rys.* . . . . . | V = 8 mm. When a rail is worn both in height and laterally, the wear of this rail has to be calculated by adding to the wear in height ($a$) half the wear in width ($b$), measured at 15 mm. below the running surface. The total must not exceed 8 mm.<br>$a + \frac{b}{2} \leqslant 8$ mm. | ... | Worn or crushed rail ends repaired by welding. | ... |

Taking the life of rails in the running roads as 50 years, second-hand rails capable of a further useful life of 25 years may be considered as 25 (50-25) years old when relaid.

On secondary lines with a daily traffic of 4 000 tons, rails worn 5 mm. (3/16″) vertically can give a further 25 years' service.

By using on secondary lines serviceable rails worn 4 to 5 mm. (5/32″ to 3/16″), removed from the main lines, the renewal figure has been reduced below 4 % per annum for new rails.

The general condition of the Belgian lines has been improved considerably since this rational method was followed, and for these reasons it was felt it would be interesting to describe it.

Among the Administrations consulted, only the Polish State Railways report that they build up the rail ends by welding. The *Belgian Nat. Rys. Co.* has recently, as an experiment, built up 20 points and crossings by oxy-acetylene welding. This System does not build up rails ends, as it considers the method to be only a palliative when applied to the crushed rail ends with the fishing surfaces also in bad condition. It prefers to replace rails with crushed ends, and to repair those taken out by cutting off their ends and welding them end to end by the electric resistance process. These rails are then used on secondary lines or in sidings, according to the amount of wear.

* * *

## Rail joints.

### a) Design of rail joints.

The joint is the weakest part of the track. The shocks set up by the wheels of passing vehicles depress the joints and ultimately deform the rails. The ensuing fatigue increases with the wheel loads and speeds. These shocks, moreover, more or less seriously damage the rolling stock, besides detracting from the passengers' comfort.

On most of the railways consulted the sleepers at the rail ends touch, or the joint is carried on a double sleeper. The sleepers near the joint are usually spaced closer together than the others, to strengthen this part of the road.

When the sleepers at the joints touch or when double sleepers are used, the fish-plates are usually flat with four bolt holes.

When the sleepers nearest to the joint do not touch, angle fish-plates or fish-plates extending below the rail foot are preferred in most cases as stiffening the joint.

The *Netherlands Railways* introduced, in 1928, a fish-plate with a special cast iron chair, arranged so that the fish-plates are only pressed against the fishing surfaces of the rails by and when the rolling loads pass.

The bolts which are shown in Table 10 are not used to tighten up the fish-plates, but to keep them in place. With this fishing arrangement, the resistance to free expansion is a minimum and holes need not be drilled near the rail ends.

The *Netherlands Railways,* however, report that this design has been discontinued as not being quite satisfactory.

At first sight, it seems to us that as the play is taken up on the load coming on, the fishing surfaces would wear more quickly. This Administration is again using a suspended joint with heavy double-flanged fish-plates.

Table 10 sums up the particulars given by the Administration consulted on the design of joints, with drawings of the most characteristic, or the most frequently used types. It also gives the information collected on sleeper spacing at the joints, methods of maintaining the fishing, and the heat treatment of the rail ends, when used.

The *Belgian Nat. Rys. Co.*, in 1933, began to use rails with the ends heat-treated by the « Arbed » process, the

effect of which is to harden the rolling surface at the ends as well as the fishing surfaces, at the same time the process improves the structure of the metal throughout its section, including the web.

The object in view is to reduce the number of fractures at the ends by avoiding crushing and unevenness at the joints, to obtain harder fishing surfaces, and finally to prevent cracks developing from the fish bolt holes.

Up to the present, joints with these rails are decidedly better than when ordinary rails of the same age carrying the same loads are used.

b) **Width of joint gaps.**

From the point of view of the good behaviour of the track, it is advantageous to reduce joint gaps.

Many railways base the width of the gap on the theory of free expansion of the rail Others, notably the *Deutsche Reichsbahn,* the *Belgian Railways,* the *Netherlands Railways* (in the case of 24-m. = 78′ 9″ rails), and the *Swiss Federal Railways,* allow smaller gaps.

If the gaps of track laid with long rails — exceeeding 30 m. (98′ 5 1/8″) — were to be based on the assumption of free expansion, the advantage of reducing the number of joints would be illusory, since the remaining gaps would be of excessive width.

In point of fact, the expansion is not free, especially if the fastenings are well tightened up. Figure 1, page 387/133, represents the expansion, starting from the middle of a rail 54 m. (177′ 2″) long in the Brussels-Antwerp electric line.

The free end moved only 3.65 mm. (0.144″) for a variation in temperature of 24.5° C. (44.1° F.).

The movement calculated on the assumption of free expansion would be

$$\frac{1}{80\,000} \times 27\,000 \times 24.5 = 8.27 \text{ mm. } (0.325'')$$

The bolts of the fish-plates connecting the rail under observation to those next to it were left loose during the test.

The coach screw does not appear to be a fastening really effective against rails creeping on the sleepers, and this deficiency has had to be made good by using special devices.

Table 11 summarises the information on this subject supplied by the Railways consulted.

Rail fastening by cotters (Ougrée) or by clips and bolts (Geo, Angleur) are sufficiently effective to make unnecessary the use of any other device for preventing the rails creeping on the sleepers.

However, the track as a whole can creep on the ballast.

The joints, therefore, must be checked periodically and re-ajusted to the proper width, in order to prevent the track suddenly getting out of line should the temperature rise considerably and suddenly, and some of the gaps become completely closed.

By reason of the heavier axle loads and the higher train speeds, every endeavour should be made to improve the joints. We would, moreover, refer in this connection to the considerations already developed in this report on the length of rails.

## Sleepers.

a) **Laying plan and sleeper spacing.**

The information received from the various railways consulted is classified in Table 12.

The general tendency is to increase the sleepering. Many systems use 5/3 sleeper per metre of track, i.e. 1 667 per km. (2 682 per mile) on important lines. In exceptional cases this number is still further increased, on account of the nature of the formation or of very unfavourable conditions of loading, as on the Brussels-Antwerp electrified line, where it is 1 815 sleepers per km. (2 920 per mile).

b) **Nature and characteristics of the sleepers used.**

Among the Systems consulted, six use both wood and metal sleepers.

The type of sleeper selected is gover-

TABLE 10.

## Joints and types of fishing.

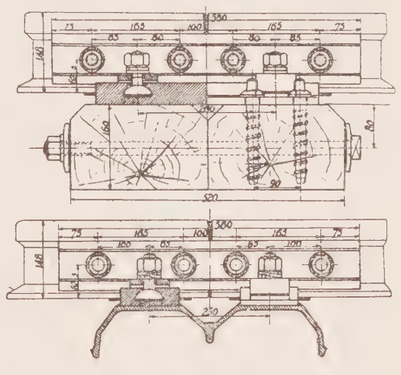
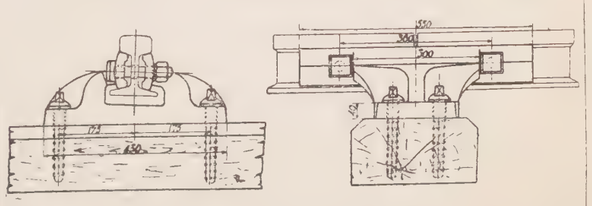
| ADMINISTRATIONS. | Types of fishing used. | Sleeper spacing at the joints. *a*, *b*, *c*, *d* in millimetres. | Methods of maintaining the fishings. | | | | Heat treatment of rail ends. |
|---|---|---|---|---|---|---|---|
| | | | Stripping and examination. | Cleaning and oiling. | Renewal of materials. | Taking up wear on the fishing surface. | |
| *Deutsche Reichsbahn* . . . . . |  | Double or contiguous sleepers. | Periodical. | ... | ... | Higher reconditioned fish-plates. | No. |
| *Austrian Federal Rys.* . . . . . | 4-hole flat fish-plates on contiguous sleepers. | Contiguous bolted sleepers.<br>$a = 260$.<br>Sleepers near joint sleepers are nearer to one another than under body of rail. | ... | ... | ... | ... | Deemed useful but not used so far. |
| *Belgian National Rys. Co.* . . . . | Flat 570-mm. fish-plates with four 25-mm. bolt holes. | Contiguous sleepers.<br>$a = 290$.<br>Sleepers near joint sleepers are nearer to one another than under body of rail. | At each complete overhaul. | Reclaimed oil. | When needed reconditioned fish-plates. | Higher reconditioned fish-plates. | No. |
| *Danish State Rys.* . . . . . | 4-hole flat fish-plates on double sleepers. | Contiguous sleepers.<br>$a = 260$ to $310$.<br>Sleepers near joint sleepers are nearer to one another than under body of rail. | ... | Graphite.<br>Bolts dipped in non-acidiferous tar. Coach-screws coated with non-acidiferous tar. | ... | Reconditioned fish-plates. | No. |
| *Netherlands Rys.* . . . . . |  <br>1928 type supported joint, and suspended joint. Consider giving up the supported joint for the suspended joint with heavy double-flanged flat fishplates. | ... | Every other year. | Mineral oil mixed with graphite. | Renewal of defective parts. | Contrivance to make up for wear. | Deemed useful but not used. |

TABLE 10 *(Continued)*.

| ADMINISTRATIONS. | Types of fishing used. | Sleeper spacing at the joints. *a*, *b*, *c*, *d* in millimetres. *(see p. 395/141)*. | Methods of maintaining the fishings. | | | | Heat treatment of rail ends. |
|---|---|---|---|---|---|---|---|
| | | | Stripping and examination. | Cleaning and oiling. | Replacement of materials. | [illegible] | |
| *State Rys. in the Dutch Indies.* . . | Suspended joint. Angle fish-plates. | $a = 547$<br>$b = 755$<br>$c = 770$<br>$d = 770$<br>13.60-m. rail. | ... | ... | In case of wear. | . | Deemed useful but not used. |
| *Hungarian State Rys.* . . . . . | Suspended joint. 6-hole angle fish-plates.<br>Contiguous sleepers. 4-hole flat fish-plates. | $a = 270$<br>$b = 700$<br>$c = 765$<br>$d = 765$<br>24-m. rail. | Periodical tightening up of nuts. | ... | ... | ... | No. |
| *Swedish State Rys.* . . . . . | Contiguous sleepers. 4-hole angle fish-plates. | $a = 260$<br>$b = 490$<br>$c = 565$<br>$d = 640$ | Periodical. | No greasing. | Use of reconditioned fish-plates. | . . | No |
| *Union of Swedish Private Rys.* . . | Suspended joint. 6-hole angle or ⌙ type fish-plates. | $a = 530$<br>$b = 690$<br>$c = 770$<br>$d = 770$<br>43.5 kgr./m. rail 15 m. long. | ... | No greasing. | Use of reconditioned fish-plates. | ... | No. |
| *Bergslagen Ry. (Sweden)* . . . . | Suspended joint:<br>43.8-kgr./m. rails. 6-hole ⌙ fish-plates.<br>45.5-kgr./m. rails. 4-hole flat fish-plates. | $a = 530$<br>$b = 690$<br>$c = 770$<br>$d = 770$<br>15-m. rail. | ... | ... | Use of reconditiondd fish-plates. | Use of « Skeius » packings. | Not tested. |
| *Swiss Federal Rys.* . . . . . | Double or contiguous sleepers. 4-hole flat fish-plates.<br>Suspended joint. 6-hole angle fish-plates. | $a = 250$<br>$b = 520$<br>$c = 558$<br>$d = 600$<br>24-m. rail. | ... | No greasing. | ... | Use of packing plates or cambered fish-plates. | No. |
| *Berne-Loetschberg-Simplon Rys.* . . | Flat or angle fish-plates. | $a = 420$ | ... | ... | ... | ... | No. |
| *Polish State Rys.* . . . . . | 4-hole flat fish-plates. | $a = 260$<br>$b = 500$<br>$c = 575$<br>$d = 650$<br>Contiguous bolted sleepers. | Periodical. | ... | When needed. | ... | Trials would be desirable. |

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TABLE 11.

## Anti-creep devices.

| ADMINISTRATIONS. | Devices used. | | Remarks about results obtained. |
|---|---|---|---|
| | Type. | Distribution. | |
| *utsche Reichsbahn* . . . | As a rule creep is prevented when the fastenings of the rails to the sleepers are kept properly tight. In particular cases special devices are fitted at the middle of the rails. | ... | ... |
| *strian Federal Rys.* . . | In the new permanent way, special devices are no longer used to overcome creep as the plates on the clips holding the rails ensure an adequate grip. | According to circumstances all the sleepers are fitted with locking plates and clips, or, one sleeper out of two only. | ... |
| *lgian National Rys. Co.* | The devices for overcoming creep comprise, for each rail of 27-m. length:<br>*a*) 2 projecting lugs fixed to the rail by 2 bolts; each lug abuts against a sleeper, connected to 5 preceding sleepers by a flat bar, placed outside the rails, at 0.35 m. from the foot of the rail.<br>*b*) These devices are supplemented according to needs by independent devices. | ... | Appreciable results. |
| *anish State Rys.* . . . . | Device sprung over the base of the rail. | 10 per 30-m. rail, the two centre ones acting in mutual opposition. 6 per 15 and 18-m. rail. | Satisfactory results. |
| *etherlands Rys.* . . . . | The fastenings well tightened up suffice in general to overcome creep. In case of necessity, use of thrust plates between the sleepers, bolted to the web of the rail. | ... | ... |
| *tate Rys. in the Dutch Indies* . . . . . | Special tightening-up devices. | ... | Result not satisfactory. |
| *ungarian State Rys.* . . | Locking plates of the « GEO » type with double washers of very great capacity (10 tons). | Every 2 sleepers or oftener. | Good results. |
| *wedish State Rys.* . . . | Anchorages. | ... | ... |
| *nion of Swedish Private Rys.* . . . . . | Anchorages and one or more tie bars per section of track connecting between them 5 sleepers along the centre line of the track. | ... | Satisfactory results. |
| *ergslagen Ry. (Sweden)* . | (1) 43.8-kgr./m. rails, thrust brackets against the sleepers, « Mathé » system.<br>(2) 45.5-kgr./m. rails: locking plates. | (1) The number is determined by the gradient of the line and the intensity of the traffic.<br>(2) Every 2 sleepers. | ... |
| *wiss Federal Rys.* . . . | Anti-creep devices of the « Fair » system. | Variable, according to creep. | Satisfactory results. |
| *erne-Loetschberg-Simplon Rys.* | Various systems. | 2 000 per km. | Good results. |
| *olish State Rys.* . . . . | Special devices applied to the centre sleepers of rail sections. | Variable number determined by trial and experience. | Satisfactory results. |

TABLE 12.

## Kind and spacing of sleepers used in main-line track

| ADMINISTRATIONS. | Number of sleepers per rail length. | Maximum number of sleepers per kilometre. | Kind of sleepers used. |
|---|---|---|---|
| *Deutsche Reichsbahn* | The spacing of the sleepers in the running road is 0.65 m., 47 sleepers per 30 m. | 1567 | Metal sleepers. Hard wood sleepers (oak or beech) and soft wood (fir) impregnated with creosote by the Rüping process. |
| *Austrian Federal Rys.* | 39 sleepers per 25 m. | 1560 | Hard wood sleepers (oak or beech) and soft wood (larch or fir) impregnated with emulsion of creosote and zinc chloride. |
| *Belgian National Rys. Co.* | 45 sleepers per 27 m.<br>98 sleepers per 54 m. (Brussels-Antwerp electrified line). | 1667<br>1815 | Metal sleepers. Hard wood sleepers (oak and beech) impregnated with creosote, Rüping process. |
| *Danish State Rys.* | 48 sleepers per 30 m. | 1600 | Sleepers of Danish fir or beech, impregnated with creosote. |
| *Netherlands Rys.* | Maximum number of sleepers: 5/3 × length of the rails in metres. | 1667 | Sleepers of oak, beech or fir, impregnated with creosote, Rüping process. |
| *State Rys. in the Dutch Indies.* | 20 sleepers per 13.60 m. | 1470 | Teak sleepers, untreated. Metal sleepers. |
| *Hungarian State Rys.* | 35 sleepers per 24 m. | 1458 | Timber sleepers (beech) impregnated with creosote, Rüping process. Metal sleepers. |
| *Swedish State Rys.* | 30 sleepers per 18 m.<br>32 sleepers per 20 m. | 1667<br>1600 | At present the timber sleepers are no longer impregnated, but there are many treated sleepers in the roads. |
| *Union of Swedish Private Rys.* | 20 sleepers per 15 m. | 1333 | Untreated fir sleepers. Tests with impregnation by arsenic will take place this year. |
| *Bergslagen Ry. (Sweden)* | Spacing of sleepers in running road: 770 mm. | ... | Sleepers impregnated with creosote (life 20 to 30 years) and untreated (life 10 to 15 years). |
| *Swiss Federal Rys.* | 41 sleepers per 24 m. | 1708 | Oak or beech sleepers impregnated with creosote, « Rüping » process (life 20 to 25 years). Metal sleepers (life 35 years). Trials with concrete sleepers have not given satisfaction. |
| *Berne-Loetschberg-Simplon Rys.* | ... | 1500 | Timber sleepers impregnated with creosote. Metal sleepers. |
| *Polish State Rys.* | 29 sleepers per 18 m. | 1611 | Wood sleepers impregnated with creosote or an emulsion of creosote and zinc chloride. |

ned by technical, local, or economic reasons. Metal sleepers, for example, cannot be used in places where they would be destroyed quickly by weather or local conditions.

Like in other large steel-producing countries, 100 000 to 200 000 metal sleepers have been used annually in Belgium since 1929.

These sleepers, with welded bearing plates without holes, behave well in the road, even on lines used by trains running at 120 km. (75 miles) per hour. In Germany, however, the practice is to use only wood sleepers in the most important roads over which the international and long-distance corridor home trains are run, such lines being included in a special class.

Oak and beech are the timbers most used for sleepers. Some countries for reasons peculiar to themselves, also use soft wood sleepers (fir, larch, etc.).

The dimensions of wood sleepers are approximately the same on all the railways.

Nearly all the countries impregnate their sleepers either with creosote, generally by the Rüping process, or with an emulsion of creosote and zinc chloride.

Teak sleepers used in the Dutch Indies are not treated. The *Swedish State Railways* no longer impregnate fir sleepers, for reasons it would be interesting to know, and the *Union of Private Swedish Railways* which used not to treat fir sleepers, is at present making trials by impregnating them with arsenic.

Among the Railways consulted, Switzerland alone gives particulars of trials with reinforced concrete sleepers, but reports that they have not given satisfaction.

### Rail fastenings

The fastenings of the rails to the sleepers ought to be capable of resisting the forces wich tend to pull them out and deform them.

The way the material, especially the sleepers, stands up largely depends on the tightness of the fastenings; we have previously mentioned the very effective part played by the fastenings in preventing the rails creeping on the sleepers.

The rail fastenings used in the running roads, with dense, heavy and fast traffic, ought therefore to be strong, easy to maintain and to keep always well tightened up.

The information received from the Administrations consulted on this subject is summarised in Table 13.

Certain railways, notably in Belgium, Denmark, Holland, and Sweden, fasten the rails directly on the sleepers, without a metal sole plate. In this design the coach screw is the usual fastening (Sweden alone still uses the spike). This method is widely used in France, and was adopted in Holland under the name of the « Est type » fastening; it is also widely used in Belgium. It gives good results on the straight and in curves of large radius, provided that the rail foot is sufficiently wide.

Several Railways, including the Reichsbahn, the Austrian Federal Rys., the Swiss Federal Rys., and the Polish State Railways., invariably insert metal bearing plates between the rails and the sleepers. Some of them use soft wood sleepers (fir, larch, etc.) and the foot of the rails used on these systems is generally narrower. Among the Railways laying the rails directly on the sleepers, some, as the Belgian Nat. Rys. Co., do not adopt this practice on curves of small radius, but use bearing plates to maintain the gauge of the track more acurately.

There are two main types of bearing plates : those fastened on to the sleepers by coach screws which serve at the same time as fastenings for the rails, 6 to 8 coach screws being used for each sleeper, and those incorporating a double fastening set, one to fix the bearing plates on the sleepers, and one fastening the rails to the bearing plates.

In this case, the bearing plates are generally fastened to the sleepers by coach screws. The rail, with its foot held bet-

ween the ribs of the bearing plate, is fastened either by coach screws, or by clips and bolts, with a spring washer between the clip and the nut, or by wedge-shaped cotters. The arguments set forth earlier in the report in connection with the use of long rails and welding them lead to the conclusion that the best rail fastening is by bolts or cotters on wide ribbed bearing plates independently secured to the sleepers.

Where metal sleepers are used, the bearing plates are generally welded to the sleepers and the rails are fastened to the bearing plates in the way used with timber sleepers, under the same conditions.

Certain Railways interpose between the rails and the bearing plate an elastic packing of compressed poplar, or of compressed wood soaked in creosote, or of bakelite, or of rubber, etc., to facilitate assembly and improve running.

### The ballast.

The particulars concerning this subject sent in by the Railways consulted are given in Table 14.

Hard broken stone is used almost exclusively on the main lines. Its dimensions generally range from 30 to 70 mm. (1 3/16″ to 2 3/4″).

The ballast used on the important main lines of the *Belgian Nat. Rys. Co.* is porphyry, quartzite, hard sandstone, or crushed slag, only exceptionally limestone, the dimensions being 40 to 60 mm. (19/16″ to 23/8″). On the secondary running roads, the dimensions are from 10 to 50 mm. (3/8″ to 2″).

The ballast must be neither friable, nor subject to cleaving by frost, nor spongy.

The ballast is submitted to gauging and shock tests.

The shock tests are made on a sample weighing 40 kgr. (88 lb.).

In the first instance all stones passing through a screen having holes of 40 mm. (1 9/16″) diameter are eliminated. The proportion of these must not exceed 12 %.

Each test comprises three operations each performed on from 4 to 5 kgr. of ballast.

The dry ballast is placed in a cast steel container of 170 mm. (6 11/16″) diameter and 150 mm. (6″) high. It is given at the rate of 2 blows a minute, 20 blows from a tup weighing 50 kgr. (110 lb.) and falling 0.50 m. (1′ 7/16″). After each blow, the vessel containing the ballast revolves through one-eighth of a turn on its vertical axis.

After the test, the ballast is emptied into a screen with six 0.50 × 0.50 m. (1′ 7 11/16″ × 1′ 7 11/16″) frames and fitted with diaphragms as under :

1st frame, a plate having 220 holes of 25 mm. (1″) diameter;

2nd frame, a plate having 600 holes of 15 mm. (19/32″) diameter;

3rd frame, wire netting with square holes 7 mm. (9/32″) side, and wire of 2 mm. (5/64″);

4th frame, wire netting with square holes 3 mm. (1/8″) side, and wire of 1 1/2 mm. (1/16″);

5th frame, a metallic fabric with square holes 1 mm. (3/64″) side, and wire of 1/2 mm. (3/128″);

6th frame, an unperforated plate.

The percentage of the quantities gathered from each sieve is determined and multiplied in order, by the following depreciation coefficient :

0 - 0.4 - 0.8 - 1.2 - 1.6 and 2.0.

The sum of these products which represents the percentage of depreciation, should be less than 0.30.

The minimum thickness of the layer of ballast between the formation and the bottom surface of the sleepers is usually 0.30 m. (12″).

We believe that it would be advantageous further to increase this thickness, in order to spread the axle loads, which have a tendency to increase, over a larger area of the formation.

From this point of view, it is always

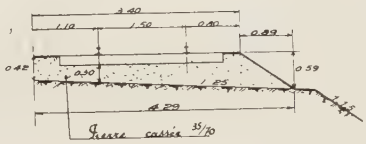
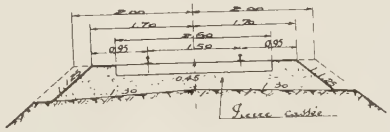
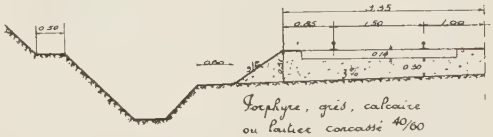
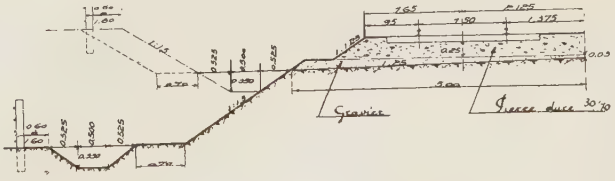
TABLE 13.

## Rail fastenings.

| ADMINISTRATIONS. | Types of fastening used. | Use of metal bearing plates on wood sleepers. | On wood |
|---|---|---|---|
| *Deutsche Reichsbahn* . . . . | *Timber sleepers :* Bearing plate fixed to sleeper by 4 coach-screws; rail fixed to plate by clips and bolts.<br>*Metal sleepers :* Bearing plate welded to sleeper; same fastening to rail. | Use generalised. | Wood packings between rail and sole plate. |
| *Austrian Federal Rys.* . | Bearing plate fixed to sleeper by 4 coach screws; rail fixed to the bearing plate by locking plates, clips and bolts. A proportion only of the sleepers is provided with the above plates; other alternating with them are fitted with ordinary plates, corresponding with the fastening of the rail by coach-screws. | ... | Packing |
| *Belgian National Rys. Co.* . . | *On timber sleepers :* 1) 6 coach screws per sleeper;<br>2) Ribbed bearing plates fixed to the sleeper by 2 coach-screws; rail fixed to the plate either by 2 coach-screws or by 2 clips and 2 bolts, or again by 2 cotters.<br>*Metal sleepers :* Ribbed bearing plates welded to the sleeper; rail fixed to the plate by 2 clips and 2 bolts, or by two cotters. | With timber sleepers, ribbed sole-plates only used an curves where R $<$ 600 m. | Trials are being made with packings between rail and metal bearing plate |
| *Danish State Rys.* . . . . . | *Fir sleepers :* Rail fastened to shouldered bearing plates, by clips and bolts or clips and coach-screws.<br>*Beech sleepers :* Rail fastened by coach-screws. | Generally up to 1931. At present, when beech sleepers are used, the rail is fixed directly on the sleeper by means of coach-screws, except in special cases. | Packings are not used any longer. |
| *Netherlands Rys.* . . . . | « *Est* » type of fastening, on hard wood sleepers: rail fixed to sleeper by 4 coach-screws, with a poplar packing in between.<br>*On cast iron chairs :* Chairs fixed to sleepers by 4 coach-screws, rail fixed to the chair by 2 clips and 2 bolts. | Generally, except with the « Est » system. | In roads using the « Est » system, packings of compressed poplar or rubber are fixed in rail seats of sleepers. |
| *State Rys. in the Dutch Indies* | *Timber sleepers :* Rail fixed by clip and coach-screws, with a metal packing plate in between.<br>*Metal sleepers :* Rail fixed by clip and bolts, with a shouldered bearing plate between. | Generally. | Packings are not used. |
| *Hungarian State Rys.* . . . | *Timber sleepers :* 1) Rail fixed by coach-screws with packing plate in between;<br>2) Bearing plates fixed to the sleeper by 4 coach-screws, rail fixed to the bearing plate by 2 clips and 2 bolts.<br>*Metal sleepers :* Bearing plates welded to the sleeper, attachment as above for rail. | Generally. | Wood packing between rail and sleeper, in fastening (2) on timber sleepers and metal sleepers is used. |
| *Swedish State Rys.* . . . | Rail fastened by 3 spikes. | Not at the present time, but will be used in the future for the running roads. | Packings are not used. |
| *Union of Swedish Private Rys.* | 1) Rail fastened by 3 spikes.<br>2) Steel bearing plates, coach-screws on the inside of the rails, spikes on the outside. | In the case of fastening (2). | Packings are not used at present. A trial of compressed poplar packings is under consideration. |
| *Bergslagen Ry. (Sweden)* . . | 43.8-kgr./m. rail: spikes and coach-screws.<br>45.3-kgr./m. rail: flat ribbed sole-plate as in Germany. | Generally. | Poplar packing between rail and sole-plate. |
| *Swiss Federal Rys.* . . . . | *Timber sleepers :* Bearing plate fixed to the sleeper by 3 coach-screws: rail fixed to the bearing plate by clips and bolts.<br>*Metal sleepers :* Same fastening. | Generally. | Poplar packing, compressed and impregnated, between rail and bearing plate. |
| *Berne-Loetschberg-Simplon Rys.* | *Timber sleepers :* Spikes and coach-screws.<br>*Metal sleepers :* Locking plates and hook bolts. | Generally. | Cellulose packing, but only for rail chairs. |
| *Polish State Rys.* . . . . | Steel bearing plates, fastened by coach-screws. | Generally. | As a trial, poplar packing, inserted between the rail foot and steel bearing plate. |

TABLE 14.

## Sections through ballast.

| ADMINISTRATIONS. | Main-line ballasting. |
|---|---|
| *Deutsche Reichsbahn* . . . . . |  |
| *Austrian Federal Rys.* . . . . . |  |
| *Belgian National Rys. Co.* . . . . |  |
| *Danish State Rys.* . . . . . |  |
| *Netherlands Rys.* . . . . . | River gravel, and in a few special cases broken stone. |
| *State Rys. in the Dutch Indies.* . . | *Sections vary much.* |

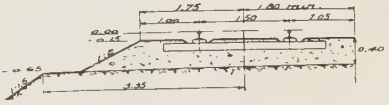
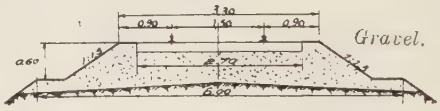
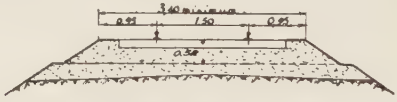
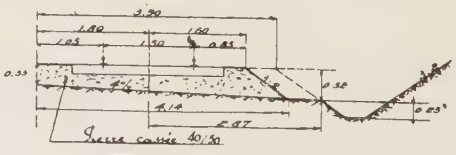
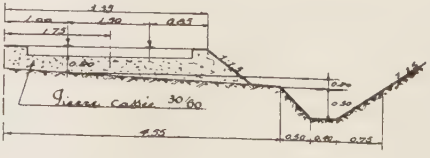



TABLE 14 *(Continued).*

| ADMINISTRATIONS. | Main-line ballasting. |
|---|---|
| *Hungarian State Rys.* . . . . . | *Broken stone.* |
| *Swedish State Rys.* . . . . . |  *Gravel.* |
| *Union of Swedish Private Rys.* . . | *Gravel :* width at top 3.30 m.; depth 0.45 à 0.50 m<br>*Macadam :* width at top 3.30 m.; depth 0.30 m. macadam, 0.30 m. gravel. |
| *Bergslagen Ry. (Sweden).* . . . . |  |
| *Swiss Federal Rys.* . . . . . |  |
| *Berne-Loetschberg-Simplon Rys.* . . | Broken stone. |
| *Polish State Rys.* . . . . . |  |

*Note:* Pierre cassée = broken stone. — Porphyre, grès, calcaire ou laitier concassé = porphyry, sandstone, limestone, broken slag. — Pierre dure = hard stone.

worth while to retain, when possible, all or part of the existing ballast, when new ballast is added, thus raising the level of the road.

When putting down new lines or carrying out complete renewals, certain Railways, such as the *Reichsbahn*, the *Austrian Federal Railways*, and the *Swiss Federal Railways*, ram or roll the ballast, before putting the permanent way proper into position. The *Belgian Nat. Rys. Co.* and the *Danish State Railways* are making experiments in the above direction.

The *Belgian Nat. Rys. Co.* uses small-size ballast of 10-25 mm. and 5-15 mm. (3/8″-1″ and 3/16″-5/8″) gauge for levelling up the track by the « measured shovel packing » method.

### The formation.

The formation must be able to stand all the load transmitted to it by the ballast.

Consequently it is most important that it should be perfectly strong and not get out of shape.

The majority of the railways consulted provide the necessary means for doing this.

When the soil is good, all that is needed is to give the surface of the formation a cross fall of 1 in 33 to 1 in 20 towards the outside of the track, to drain off into the side drains any rain water which might soak through the ballast.

The *Dutch Indies State Railways* adopt the practice of ramming, in successive layers, the filling forming the railway embankments. This precaution, which is not always taken, is nonetheless to be recommended.

When the soil is not firm, the railways usuallly construct a network of transverse and longitudinal drains in the formation, which lead the water into the discharge drains provided.

When even this method is still inadequate, the top layer of the formation is replaced by a layer of slag. The *Belgian Nat. Rys. Co.* has obtained good results in the most unfavourable circumstances by using a layer of screened ashes varying from 0.30 to 0.60 m. (1′ to 2′) in depth.

### Bridges and other structures.

The replies received show that most of the Railways consulted take into account the dynamic action of high-speed trains, by increasing the stresses in the details of metal under-bridges as designed to carry static loads, by a coefficient of impact depending principally on the span of the members.

Some Railways make allowance in the calculations for the effect of wind, braking, hunting, and temperature variations.

The theoretically permissible stresses clearly depend upon the conditions assumed in the calculations for the bridges and can be the higher the more factors are taken into consideration.

Direct loading and bending tests are sometimes made to check the behaviour of under-bridges under heavy loads, and also sometimes to verify the methods of computation adopted.

Most of the administrations prefer designs of metal bridges with the permanent way resting directly on the ballast, especially in towns and over highways in busy areas where road traffic is naturally dense. When the available height does not allow of ballasting, the railway sleepers are often fixed to the longitudinal members of the bridge and the spaces between closed by means of plates or water-tight slabs.

Certain railways recommend a greater depth of ballast on bridges than in the ordinary road.

Several railways weld the rail joints on long bridges in conjunction with the use of special expansion devices. In any case the rail joints should be arranged to come over the intermediate piers of the bridges.

Long-span bridges are also provided with check rails having suitably wide

lead-ins. The ends of the two check rails are frequently connected together on the centre line of the track to ensure any derailed vehicle having to clear the bridge at least more or less in its normal position.

## Curves.

### a) Gauge on curves.

The rules adopted differ considerably from one railway to another (Table 15).

No railway exceeds the figure of 30 mm. (1 3/16″) for gauge widening, but some of them consider that this amount should be worked to on laying the track, with an additional working tolerance of 5 mm. (3/16″) (*Belgium*), whilst others make it the absolute maximum (*Sweden*). *Germany* and *Denmark* never exceed 15 mm. (5/8″)).

Opinions differ equally as to the radius above which the gauge should be widened. The greatest divergence is to be found between Sweden (2 mm. with 1 000 m. radius = 5/64″ with 50 chains radius) and the group containing Germany and Denmark (5 mm. with 300 m. radius = 3/16″ with 15 chains radius).

Undoubtedly the way stock runs through the curves should be improved so as to reduce the gauge widening and thus diminish the amplitude of hunting movements.

### b) Layout of curves.

All the Railways consulted adopt parabolic transitions, generally of the third degree, which involve a transition ramp of constant gradient. The *Dutch Indies State Railways* make use of the parabola of the fifth degree, the transition ramp being nevertheless linear. In general parabolic transitions are dispensed with for curves having a radius above 3 000 m. (150 chains), or when the difference of curvature of the curves to be joined is less than 1 : 3 000.

When the question is one of transitions between reverse curves, the tendency is to consider that the two curves are independent of one another, when between the origins of the parabolic transitions there is to be found an intermediate straight length of from 10 m. (32′ 9″). [*Switzerland*, V max = 100 km. (62 miles) per hour to 50 m. (164′). — *Germany*, V max = 120 km. (75 miles) per hour, and over.] When it is not possible to provide a straight section of sufficient length, it would appear preferable to adopt a solution without any intermediate straight length, thus having a layout with an inflexion point.

The length admissible for progressive transitions varies greatly, as do the rules applied in computing it; this will be realised from Table 16. Certain railways leave the fixing of this length to the judgment of the officials responsible for the work; others establish a scale of lengths in terms of the speed, and still others evolve a relation between the length and the radius. In general, according to circumstances, the lengths vary between 6.72 m. (22′ 5/8″) (*Dutch Indies*) and 200 m. (656′) (*Belgium*).

### c) Superelevation on curves.

Generally the maximum superelevation (cant) is fixed at 150 mm. (6″). The *Polish State Railways*, however, have adopted 130 mm. (5 1/8″) as the maximum, the *Netherlands* and *Swedisch* 120 mm. (4 3/4″), the *Hungarian* 110 mm. (4 3/8″). The *Dutch Indies State Railways* work to a maximum of 85 mm. (3 3/8″), but intend to raise it shortly to 100 mm. (3 15/16″) (equivalent to 150 mm. = 6″ in standard gauge track). The *German* and *Belgian* Railways state that in special cases they use a superelevation of 160 mm. (6 5/16″).

In Belgium this increase will only be resorted to at places only in the running roads where trains are not stopped except for unforeseen reasons, as when trains are stationary, even with 120 mm. (4 3/4″) of superelevation, the tilt already causes much inconvenience (diffi-

culties with the doors, leakage of oil from the axle boxes).

As regards the progressive increase of the superelevation the Railways unanimously agree that the superelevation gradient (cant developing incline) is to be superposed on the transition, as required by theory; the *Dutch Indies State Railways* alone make good the cant on a part of the transition. Most of the Administrations also arrange for the superelevation ramp, whose length is generally subject to a lower limit, to be possibly extended beyond the parabolic transition.

In this case, the *German* and *Swiss* Railways require the excess to be extended into the circular curve, whilst the *Belgian Nat. Rys. Co.* and the *Netherlands Railways* so far have made good the missing cant in the straight part of the alignment.

The length of the transition gradients is generally determined so as to produce an inclination of 1 in 1 000 — at least for high speeds — with an absolute maximum of 1 in 400. It should be noted that this maximum limit on the narrow-gauge *Dutch Indies State Railways*, when transposed to a standard-gauge track is equivalent to about 1 in 270.

So far as we have been able to deduce from the replies received, the *Swiss Railways* (two Systems) alone build up the cant by superelevating the outer line of rails and simultaneously lowering the inner line.

The *German* and *Danish Railways*, the *Belgian Nat. Rys. Co.* as well as the *Union of Private Swedish Railways* allow negative cant being given.

On the *Belgian Nat. Rys. Co.*, the superelevation on the straight is limited to 60 mm. (2 3/8″) — with a tendency to increase it — without this involving any reduction in speed over the through part. This enables the speed to be increased on the branch line.

In diverging curves in points and crossings, the superelevation is limited to 90 mm. (3 1/2″) when the branch line is of some importance, otherwise it may be as much as 150 mm. (6″).

In either case, the speed over the diverging road is limited to 20 km. (12.4 miles) an hour.

d) **Speed restrictions on curves.**

When there are local restrictions (e. g. a level crossing, or a building preventing the track or the constructional gauge being given cant to the desired extent) or when the cant reaches the maximum agreed value, the highest speed to be authorised on a curve is always conditioned by both the radius and the superelevation. Opinions differ, however, as to how this dependence should be attained in practice.

There are empirical methods and theoretical formulae for calculating the superelevation.

The empirical formulae which we meet on the railways in question are nearly always of the form :

$$h = a \frac{V}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which

$h$ represents the superelevation in millimetres;
V the speed in km./hour;
R the radius in metres, and
$a$ a constant.

The values allotted to $a$, according to the various Railways, are as follows :

| | |
|---|---|
| Polish State Railways (for V > 50 km./h. i. e. 31 m. p. h. . . . . | 600 |
| Netherlands and Swedish State Rys. | 667 |
| Swiss Federal Railways . . . . | 700 |
| Belgian Nat. Rys. Co. (for V = 70 km./h. i. e. 43.5 m. p. h. . . . | 825 |

It should be noted that the *Swiss Federal Railways* authorise the reduction of the cant to two-thirds of its normal value for running roads in stations, which reduces the value of $a$ to 467.

The *German* and *Danish* Railways normally use the equation :

$$h = 8 \frac{V^2}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

TABLE 15.

## Curves : Gauge widening and speed restrictions.

| ADMINISTRATIONS. | Gauge widening on curves.<br>W = gauge widening, in millimetres;<br>R = radius, in metres). | Rules for speed restrictions in terms of the radius, the superelevation being normal.<br>V = speed, in km./h.; h = superelevation (cant), in millimetres. |
|---|---|---|
| *Deutsche Reichsbahn* . . . | 300 ⩾ R > 250 W = 5 mm.<br>250 ⩾ R > 160 W = 10 mm.<br>160 ⩾ R W = 15 mm. | V max. = $4.5 \sqrt{R}$.<br>For R between 350 and 180 m.;<br>V max. varies between $4.3 \sqrt{R}$ and $3.7 \sqrt{R}$. |
| *Austrian Federal Rys.* . . | 600 > R ⩾ 500 W = 10 mm.<br>500 > R ⩾ 400 W = 15 mm.<br>400 > R ⩾ 300 W = 20 mm.<br>300 > R ⩾ 200 W = 25 mm.<br>200 > R W = 30 mm. | R = 625 570 450 400 350 300.<br>V = 100 95 85 80 75 70.<br><br>R = 280 240 200 180 150.<br>V = 65 60 55 50 45. |
| *Belgian National Rys. Co.* | 600 > R ⩾ 300 W = 10 mm.<br>300 > R ⩾ 200 W = 20 mm.<br>200 > R W = 30 mm.<br>Absolute maximum : 35 mm. | R = 800 700 600 500 450 400 300 200 150 100.<br>V = 120 110 100 90 80 70 60 50 40 20.<br>When R ⩾ 400 m., the above figures can be increased by 10 km./h., when the running speed range is not over 10 km./h. |
| *Danish State Rys.* . . . . | 300 > R ⩾ 250 W = 5 mm.<br>250 > R ⩾ 160 W = 10 mm.<br>160 > R W = 15 mm. | *« Lightning » train lines :*<br>« Lightning » trains and railcars, V = $4.5 \sqrt{R}$.<br>Steam trains V = $4.3 \sqrt{R}$.<br>*Other lines :* V = $3.8 \sqrt{R}$ to $4 \sqrt{R}$.<br>V. max. of « lightning » trains : 120 km./h.; other trains : 100 km./h. |
| *Netherlands Rys.* . . . . | 500 ⩾ R > 300 W = 7 mm.<br>300 ⩾ R > 180 W = 15 mm.<br>180 ⩾ R W = 20 mm. | R = 1 000 750 500 300 150 100.<br>V = 100 90 75 60 45 30. |

| | | | |
|---|---|---|---|
| *State Rys. in the Dutch Indies* . . . . . | 500 > R ⩾ 300<br>300 > R ⩾ 250<br>250 > R ⩾ 200<br>200 > R | W = 5 mm.<br>W = 10 mm.<br>W = 15 mm.<br>W = 20 mm. | R = 500 450 400 350 300 275 225 200.<br>V = 90 85 80 75 70 65 60 55.<br>R = 180 140 120 100.<br>V = 50 45 42 40. |
| *Hungarian State Rys.* . . | 800 ⩾ R > 400<br>400 ⩾ R > 250<br>250 ⩾ R > 180<br>180 ⩾ R | W = 10 mm.<br>W = 20 mm.<br>W = 25 mm.<br>W = 30 mm. | R = 1 300 1 200 1 100 1 000 900 800 700 600 500 400.<br>V = 120 115 110 105 100 95 90 85 80 75.<br>R = 350 300 275 250 200 180 150 120 100.<br>V = 70 65 60 55 50 45 40 30 25. |
| *Swedish State Rys.* . . . | New regulations are being drawn up. | | |
| *Union of Swedish Private Rys.* . . . . . | R ⩾ 300 m. | W = 13 mm. | R = 600 500 400 350 300.<br>V = 90 80 75 70 60. |
| *Bergslagen Ry. (Sweden)* | R = 1 000 900 800 700 600 500 450 400.<br>W = 2 3 4 5 6 8 9 11.<br>R = 350 300 250 200 150 120 90.<br>W = 13 15 18 21 24 26 28. | | R = 600 500 400 350 300.<br>V = 90 80 75 70 60. |
| *Swiss Federal Rys.* . . . | 800 ⩾ R > 400<br>400 ⩾ R | W = 10 mm.<br>W = 20 mm. | R = 600 550 500 450 400 350.<br>V = 100 95 90 85 80 75.<br>R = 300 260 230 200 175.<br>V = 70 65 60 55 50. |
| *Berne-Loetschberg-Simplon Rys.* | W = 20 mm. maximum. | | ... |
| *Polish State Rys.* . . . . | 500 > R ⩾ 350<br>350 > R ⩾ 250<br>250 > R | W = 10 mm.<br>W = 20 mm.<br>W = 25 mm. | R = 900 800 700 600 500 400.<br>V = 100 95 90 85 80 75.<br>R = 350 300 250 200 180.<br>V = 70 65 60 50 45. |

The Hungarian and Austrian formulae are worthy of special mention, as these appear to be deduced from extremely careful experiments and are indicative of the desire to reconcile at one and the same time, stability of running, preservation of the stock and attainment of high speeds.

The *Hungarian* formula is as follows :

$$h = \frac{2\,000}{200 + V} \cdot \frac{V^2}{R} \quad . \quad . \quad . \quad (3)$$

If the values of 60 and 120 km./h. are given in turn to V we obtain respectively :

$$h = 7.7\,\frac{V^2}{R} \quad \text{and} \quad h = 6.2\,\frac{V^2}{R} \quad (4) \text{ and } (5)$$

In Austria, liberty is left to the executive staff to vary the superelevation between the values :

$$h = \frac{13\ V^2/R}{1 + 0.025\ V^2/R}$$

$$\text{and} \quad h = \frac{9\ V^2/R}{1 + 0\ 025\ V^2/R} \quad . \quad (6) \text{ and } (7)$$

As will appear from the following, a value lying approximately between 8 and 20, may be given to $V^2/R$. By substituting in the denominator in equation (6) the mean value 14 for $V^2/R$, this equation becomes :

$$h = 9.6\,\frac{V^2}{R} \quad . \quad . \quad . \quad . \quad (8)$$

Formula (7) becomes under the same conditions:

$$h = 6.7\,\frac{V^2}{R} \quad . \quad . \quad . \quad . \quad (9)$$

The German, Austrian and Danish replies indicate, however that in exceptional cases the superelevation may be reduced to the value

$$h = 11.8\,\frac{V^2}{R} - 90 \quad . \quad . \quad (10)$$

This expression falls into the class of theoretical formulæ, which we will now deal with.

The cant in a road is intended to counteract, from the point of view of comfort, safety and preservation of the stock, the effects of centrifugal force on curves.

Reduced to the ton as unit of weight, the centrifugal force is represented by the equation :

$$C = \frac{v^2}{g\,R} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$v$ representing the speed expressed in m./sec., and

$g$ the acceleration due to gravity.

If it is desired to express the speed in km./h., and giving $g$ its numerical value, we get :

$$C = \frac{V^2}{127\ R} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

The cant given to the track has the effect of causing the centrifugal force to be opposed by a horizontal force resulting from the splitting up of the weight along a line perpendicular to the track at the point under consideration, and a horizontal line on a vertical plane transverse relatively to the track. This component acts towards the centre of the curve run over if the cant is applied in the usual manner.

It is thus noticed that each millimètre of superelevation introduces a centrifugal force very nearly equal to $\frac{1}{1\,500}$, in other words, every time the superelevation is increased by 1.5 mm., there is balanced 1 kilogramme of centrifugal force.

Consequently, when $h$ mm. of superelevation is given, the centrifugal force is reduced by a quantity

$$H = \frac{h}{1\,500} \quad . \quad . \quad . \quad . \quad . \quad (13)$$

so that there remains an unbalanced excess expressed by

$$Q = C - H = \frac{V^2}{127\ R} - \frac{h}{1\,500} \quad . \quad . \quad (14)$$

TABLE 16.

## Layout of transition curves and determination of the superelevation (cant) on lines run over at high speeds.

| ADMINISTRATIONS. | Rules for laying out transition curves : Between a circular curve and a tangent: $x$ = abscissæ relatively to the straight, $y$ = ordinates and to the tangent point, L = length of the transition curve. | Rules for laying out transition curves : Between two circular curves — in the same direction. | Rules for laying out transition curves : Between two circular curves — reverse. | Rules used for calculating the superelevation. $h$ = superelevation in millim., V = speed in km./h., R = radius in metres. | Maximum cant on the main lines. | Development and allocation of the superelevation in the transition curves (relative gradient of the two lines of rails = $p$, in mm. per m.). | Use of cant on the straight or of negative cant on curves. | Rules governing speed restrictions when the track cannot be given the required cant. |
|---|---|---|---|---|---|---|---|---|
| *Deutsche Reichsbahn* | Cubic parabola, so long as R < 3 000. | Cubic parabola. | No inflection without a connecting straight 50 m. long. | normal $h = \frac{8\ V^2}{R}$<br>minimum $h = 11.8\ \frac{V^2}{R} - 90$ | 150 mm. exceptionally 160 mm. | Linear development along the length of the parabolic transition, extended as necessary into the circular curve. | Yes, when it is advantageous from the point of view of speed. | $V = \sqrt{\frac{h + 90}{11.8} \cdot R}$ |
| *Austrian Federal Rys.* | Cubic parabola. | — | No connecting straight if there are parabolic transitions. | $\frac{9\ \frac{V^2}{R}}{1 + 0.025\ \frac{V^2}{R}} < h < \frac{13\ \frac{V^2}{R}}{1 + 0.025\ \frac{V^2}{R}}$ | 150 mm. | Linear development $p < \frac{1}{6\ V}$<br>V = maximum speed. | No. | $V = \sqrt{\frac{h + 90}{11.8} \cdot R}$<br>V = maximum speed. |
| *Belgian National Rys. Co.* | Cubic parabola when $\frac{V^2}{R} < 5.75$.<br>L $\simeq$ 10 V$h$ ($h$ in metres) practically<br>L = 40. 60. 80. 100. 120. 160. 200. | Cubic parabola when $V^2 \left(\frac{1}{R_2} - \frac{1}{R_1}\right) > 5.75$. | So far as possible elimination of connecting straight between the origins of the 2 parabolic transitions. | $h = 11.8 \frac{V^2}{R}$ for V $\leqslant$ 70<br>V = actual speed<br>$h = 11.8\ \frac{70\ V}{R} = 826\ \frac{V}{R}$ for V > 70 | 150 mm. | Linear development along the length of the curve $p = 0.0025$<br>For lines carrying fast traffic this figure is reduced to<br>$p \simeq \frac{1}{10\ V}$ | In junctions having a straight branch, cant is sometimes given to help the curved branch. In junctions on curves, negative cant may be given to the branch to help the through road. | $V = \sqrt{\frac{h + 90}{11.8} \cdot R}$<br>As a trial<br>V = maximum speed. |
| *Danish State Rys.* | « Lightning » train lines. Transition curve (cubic parabola) when R < 3 000 m. | Cubic parabola when $\frac{R_1 R_2}{R_1 - R_2} \leqslant 3\,000$ m. | Straight alignment $\geqslant$ 30 m. | $h$ normal $= 8\ \frac{V^2}{R}$<br>$h$ minimum $= 11.8\ \frac{V^2}{R} - 90$<br>In a few exceptional cases on curves of radius R $\leqslant$ 700 m.<br>$h$ minimum $= 11.8\ \frac{V^2}{R} - 105$ | 150 mm. | Normally $p = \frac{1}{10\ V}$<br>Exceptionally $p = \frac{1}{8\ V}$ | Yes, in switches on curves. | V maximum $= \sqrt{\frac{h + 90}{11.8} \cdot R}$<br>V minimum $= \sqrt{\frac{h}{8} \cdot R}$<br>Exceptional case<br>V maximum $= \sqrt{\frac{h + 105}{11.8} \cdot R}$ |
| | Steam train lines. Transition curve, when R < 2 200 m. | Cubic parabola when $\frac{R_1 R_2}{R_1 - R_2} \leqslant 2\,200$ m. | | | | | | |
| *Netherlands Rys.* | Cubic parabola.<br>L = 80 for 400 $\geqslant$ R > 180<br>L = 60 for 1 000 $\geqslant$ R > 400<br>L = 40 for R > 1 000 | Cubic parabola when $\frac{R_1 R_2}{R_1 - R_2} \leqslant 1\,500$ m. | ... | Up to the present<br>$h = \frac{2\ V\ (\text{in m./h.})}{3\ R\ (\text{in m.})}$<br>Formula under consideration :<br>$h = 8\ \frac{V^2}{R}$ | 120 mm. | For preference $p = 0.001$<br>If L is too small the cant developing gradient will extend into the straight alignment and into the circular curve, if necessary. | No. | The speeds are fixed in such a manner that they may be maintained even if the superelevation is lacking. |

TABLE 16 *(Continued)*.

| ADMINISTRATION | Rules for laying out transition curves. Between a circular curve and a tangent: x = abscissæ, y = ordinates relatively to the straight and to the tangent point, L = length of the transition curve. | Between two circular curves: in the same direction. | Between two circular curves: reverse. | Rules used for calculating the superelevation. h = superelevation in millim., V = speed in km./h., R = radius in metres. | Maximum cant on the main lines. | Development and allocation of the superelevation in the transition curve (relative gradient of the two lines of rails = $p$, in mm. per m.). | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|
| *State Rys. in the Dutch Indies.* | Parabola of the 5th degree $6.721 < L < 109.780$ | ... | ... | According to a special table. | 85 mm. (100 mm. contemplated for narrow gauge). | Linear development along the first three quarters of the length of the transition. | No. | $\frac{G}{R} = \frac{1.25}{Z} = 119$ h. Z = height of the centre of gravity of the vehicle in metres. h = superelevation in metres. |
| *Hungarian State Rys.* | Cubic parabola. | Cubic parabola. | ... | $h = \frac{2\,000}{200 + V} \cdot \frac{V^2}{R}$ | 110 mm. | Linear development along the length of the transition curve. | No. | On the main lines, nothing prevents the provision of the cant. |
| *Swedish State Rys.* | The new instructions have not yet been formulated. | | | | | | | |
| *Union of Swedish Private Rys.* | « Nalenz » method of curve adjustment. | ... | ... | ... | 120 mm. | The superelevation at each point according to the radius. | Yes, when necessary. | Problem solved according to circumstances. |
| *Bergslagen Ry. (Sweden)* | Parabola $y = \frac{x^3}{R}$ L = 50 | ... | ... | ... | ... | Cant built up along the length of the transition. | No. | No such case exists. |
| *Swiss Federal Rys.* | Parabola $y = \frac{x^3}{6\ LR}$ | Cubic parabola. | If the intermediate straight section is less than 10 m., the ends of the cant gradients should touch one another on the straight alignment. | $h = 700\ \frac{V}{R}$ | 150 mm. | Linear development along the whole length of the transition, extended as required into the circular curve. $p = 0.0025$ Raising of the outer line and lowering of the inner line of rails. | No. | Cant reduced by 1/3 without decrease in speed whilst passing through stations. |
| *Berne-Loetschberg-Simplon Rys.* | L = 400 × $h$ ($h$ in metres). | ... | ... | $h = 700\ \frac{V}{R}$ | 150 mm. | Linear development along the whole length of the curve. | ... | Is decided according to conditions. |
| *Polish State Rys.* | Parabola. | ... | ... | $h = 11.8\ \frac{V^2}{R}$ for $V \leqslant 50$ $h = 600\ \frac{V}{R}$ for $V > 50$ | 130 mm. | Development at the beginning or end of the curves. $p = 0.0015$ for V = 61.80 km./h. $p = 0.001$ for V = 81 and above. | No. | No such case exists. |

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The preceding formula establishes a relationship between V, R, $h$ and Q.

Thus, when a vehicle travels at constant speed over a circular curve, well laid out but with faulty superelevation, the horizontal thrust Q varies with $h$ and may assume sometimes positive and sometimes negative values, passing through zero. If the curvature were irregular, although there be uniform superelevation, the thrust would also vary.

Theoretically, R and $h$ must be assumed constant, and in order to find the definite relation between V, R and $h$ it is necessary to adopt a given value for Q. This is where the difficulty lies.

In order to neutralise the centrifugal force completely, it is necessary that :

$$Q = \frac{V^2}{127\ R} - \frac{h}{1\ 500} = 0. \quad . \quad (15)$$

Whence :

$$h = 11.8\ \frac{V^2}{R} \quad . \quad . \quad . \quad (16)$$

$h$ being expressed in millimetres.

In the group of Railways with which we are concerned, this formula is used only by Belgium, for speeds below or equal to 70 km. (43.5 miles) per hour, and Poland for speeds up to 50 km. (31 miles) per hour.

Whilst this superelevation may be perfect for lines with all the trains travelling at the same speed, it has certain practical drawbacks in other cases.

Indeed, if the formula contemplated is applied to a line carrying mixed traffic (fast and slow simultaneously), the cants calculated for the highest speeds are too ample for slow trains and result in the inner rail being crushed down. Contrariwise, if they are calculated for low speed, the fast trains would be neither comfortable nor safe enough.

If, on the other hand, the formula is to be used for calculating the permissible speed in terms of the radius and the cant, it is found, to begin with, that very large radii are required, with the cant limited to 150 mm. (6″) if the present-day high speeds are to be authorized. Indeed, for a speed of 120 km. (75 miles) an hour, it would require :

$$R = 11.8 \times \frac{120^2}{150} = 1\ 130 \text{ m. } (56.5 \text{ ch.})$$

If the speed to be allowed over the deviated branch in switches is to be found, the result is — at least theoretically — that trains cannot be run over them, as usually these curves are laid without any cant. Indeed :

$$V = \sqrt{\frac{h \times R}{11.8}}$$

when $h = 0$, $V = 0$.

These considerations have led all the Railways to use in many cases wide tolerances in the superelevation. It is appropriate therefore to investigate the standards of safety under which the traffic circulates. In other words, the practical solution of this problem lies in the limitation of the excess Q (formula 14) of the centrifugal force or of the transverse thrust at a definite value other than zero.

Coming back to equation (14), its solution in relation to $h$ gives :

$$h = 11.8\ \frac{V^2}{R} - 1\ 500\ Q. \quad . \quad (17)$$

A suggested value for Q is 0.060 (60 kgr. = 132 lb. per ton of weight); the expression for $h$ then becomes :

$$h = 11.8\ \frac{V^2}{R} - 90. \quad . \quad . \quad (18)$$

This is the superelevation formula adopted by the *German Railways*. It is given also in the same form in the « Technische Vereinbarungen », 1st October 1931 supplement to the 1930 edition.

0.060 is the value found from practical observation, the transverse strength of the track being taken into account. If

Q were taken, for example, as 0.070, the result would be :

$$h = 11.8 \frac{V^2}{R} - 105. \quad . \quad . \quad . \quad (19)$$

which is the formula adopted by the *Danish Railways* when R = 700 m. (35 chains).

According to experiments made in Italy (*Rivista Tecnica* of the 15th August 1935; *Revue Générale des Chemins de fer,* May 1936) the value of Q may be as high as 0.10, which would give :

$$h = 11.8 \frac{V^2}{R} - 150 \quad . \quad . \quad . \quad (20)$$

Referring back to equation (14) and solving it for V, we find :

$$V = \sqrt{\frac{h + 1\,500\,Q}{11.8} . R} \quad . \quad . \quad (21)$$

If we substitute for Q the values 0.060, 0.070, and 0.10, we obtain respectively :

$$V = \sqrt{\frac{h + 90}{11.8} . R} \quad . \quad . \quad (22)$$

$$V = \sqrt{\frac{h + 105}{11.8} . R} \quad . \quad . \quad (23)$$

$$V = \sqrt{\frac{h + 150}{11.8} . R} \quad . \quad . \quad (24)$$

In the particular case of $h = 150$, formula (22) becomes :

$$V = 4.5 \sqrt{R} \quad . \quad . \quad . \quad (25)$$

and when $h = 0$.

$$V = 2.8 \sqrt{R} \quad . \quad . \quad . \quad (26)$$

The determination of the value of Q is a question of judgment. It is deduced from braking tests. Actually an excess centrifugal force not balanced by the superelevation corresponds to a centrifugal acceleration 9.81, or nearly 10 times greater. An acceleration of 0.60 m. (1.97′) per sec. per sec. corresponds therefore to a value of Q of 0.06 ton; and an acceleration of 1 m. (3.28′) per sec. per sec. to a value of 0.10 ton. For the passenger the sensation is approximately the same, whether he is subjected to a force acting transversely to the vehicle in which he is sitting or longitudinally. Accelerations or retardations of 0.60 m. per sec. per sec. are not felt by the passenger who finds those of 1 m. per sec. per sec., which are not uncommon, very bearable.

The question of comfort having thus been settled, let us now deal with that of safety, by investigating the resistance of the vehicle to overturning.

The transverse force exerted on the outer rail, when the superelevation is calculated for example by formula (18), is uniformly equal to 60 kgr. (132 lb.) per ton weight of the vehicle. This force, which acts at the height ($c$) of the centre of gravity, produces an overturning moment which is likewise constant. Letting $e$ represent the transverse displacement of the centre of gravity resulting from the play of the springs, and using for calculating the coefficient of resistance to overturning $m$, the formula which has been mentioned in the report drawn up by Messrs. BAUMANN and JAEHN (Question III, Cairo Congress) and which was reproduced in the December 1932 *Bulletin,* pp. 2293/94,

$$m = \frac{0.750 - e}{Q \cdot c} = \frac{0.750 - e}{\left(\frac{V^2}{127\,R} - \frac{h}{1\,500}\right) . c} \quad . \quad (27)$$

substituting for Q (the unbalanced excess) the value given by equation (14) above.

For locomotives, at the present time $c$ tends towards the value 2.250 m. (7′ 4 19/32) and $e$ may be evaluated at 0.100 m. (4″). By substituting these values, $m$ equals 4.8, a figure which would appear to be amply sufficient. It is true that if the ideal formula (16) were used $m$ would have an infinitely great value, but the degree of security

against accidents would not increase in the same measure.

The Danish formula gives a coefficient of 4.1, but the Italian one would only leave 2.9.

This shows that vehicles with a low centre of gravity, such, for example, as motor coaches, have a much greater coefficient of stability, and it might be deduced therefrom that these vehicles can be run at higher speeds. This is the tendency on certain railways.

An important question still remains to be investigated : that of curves without parabolic transitions. To what extent can the absence of transition curves influence the speeds in use?

Starting with a curve of zero superelevation, we believe the following reasoning holds good.

An axle meeting a circular curve tangential to a straight alignment is suddenly deviated under the effect of a centrifugal force proportional to $\frac{V^2}{R}$. This lateral thrust which acts immediately with its maximum intensity, produces a kind of « sudden loading » which doubles the forces at striking.

In order not to exceed the value of $Q = 0.60$ allowed above, it would be necessary, according to this theory, to reduce its value to 0.30 in the formula. But the comparison of the results obtained in practice show that the formula so obtained would be much too restrictive, as the spring suspension of vehicles does make the entry into the curves smoother, and as $Q = 0.045$ may be admitted. Formula (21) thus becomes :

$$V = \sqrt{\frac{0 + 67.5}{11.8} \cdot R} = 2.4 \sqrt{R} \quad (28)$$

On comparing this equation with (26) it is noticed that the absence of transition curves reduces the speed by $0.4 \sqrt{R}$. Taking as an example a curve of 800 m. (40 chains) radius, the maximum speed would have to be diminished from 79 to 68 km. (49 to 42.3 miles) an hour.

In a curve without transitions, but nevertheless having superelevation starting at its origin, the speed law ought to be the same as for curves without superelevation, since the sudden development of the centripetal force is felt in the one case as in the other, in spite of the superelevation. However, it appears permissible, in practice, not to apply this reasoning fully, but to adopt in this case, in a general way the formula

$$V = \sqrt{\frac{h + 67.5}{11.8} \cdot R} \quad . \quad . \quad (29)$$

which gives in the particular case when $h = 150$ :

$$V = 4.3 \sqrt{R} \quad . \quad . \quad . \quad (30)$$

Another conclusion can be drawn from a comparison of these formulæ : that the absence of a transition curve may be compensated by an increased superelevation. Indeed, if $h_1$ represents the superelevation of a curve provided with transitions, and $h_2$ that of a curve without them, we get, by equating the two expressions for V :

$$h_1 + 90 = h_2 + 67.5$$

whence $\Delta h = 22.5$.

In like manner, from the point of view of speed, we can deduce the equivalent values of curves with or without cant, or of curves with or without parabolic transitions. To quote a few figures, the speed of 120 km. (75 miles) an hour may be authorised for radii of 710 m. (35 1/2 chains) and over, when full cant (150 mm. = 6″) and transitions are provided; for radii of 780 m. (39 chains) and over when the full cant is used but there are no transitions; for radii of 1 840 m. (92 chains) with

transitions but no cant (1), and for radii of 2 500 m. (125 chains) and over when there is neither transition nor cant. In the case of negative cant ($h < 0$) the theory expounded is also applicable.

There is finally the layout, fortunately very rare, of reverse curves which are tangential to one another without any intermediate straight or transition curve. The cant is always zero at the tangential point. The shock received in passing from one curve to the other will be proportional to

$$V^2\left(\frac{1}{R_1}+\frac{1}{R_2}\right).$$

Applying formula (29) to this case we have :

$$V^2\left(\frac{1}{R_1}+\frac{1}{R_2}\right)=\frac{67.5}{11.8}=5.7 \quad (31)$$

or again

$$V = 2.4\sqrt{\frac{R_1 R_2}{R_1+R_2}}.$$

If $R_1 = R_2 = R$ ,we would have :

$$V = 2.4\sqrt{\frac{R}{2}} \quad \text{or} \quad V = 1.7\sqrt{R}.$$

Therefore, when for example a tangent point connects two curves of 1 800 m. (90 chains) without cant or transitions on which a speed of about 100 km. (62 miles) an hour is authorized, the pair of curves will act like a curve of 900 m. (45 chains) without cant or transitions; the speed will be limited to 72 km. (44.7 miles) an hour.

According to (14) we have, when $h$ = 150 mm. (6″) :

$$Q=\frac{V^2}{127\,R}-\frac{h}{1\,500}=\frac{V^2}{127\,R}-0.100 \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

When using the formulæ « of minimum cant » that we have advocated and explained at length above, the thrust is constant for all values of V. On the diagram, figure 4, it is represented by lines parallel to the axis of the V's.

With the many formulæ of form (1), there remains a thrust :

$$Q=\frac{V}{127}\cdot\frac{V}{R}-0\,100=\frac{V}{127}\cdot\frac{h}{a}-0.100=\frac{1.18}{a}V-0.100.$$

The diagram (fig. 4) represents the variation of the thrust for the different cases which arise.

The *German* and *Danish* rule $h = 8\,\frac{V^2}{R}$ also gives a constant thrust, since

$$Q=\frac{150}{8\,.\,127}-0.100=0.047.$$

The *Hungarian* formula gives rise to a thrust

$$Q = 0.00059\,V + 0.018,$$

whilst the *Austrian* formulæ give respectively

$$Q = 0.128 - 0.100 = 0.028.$$
$$Q = 0.225 - 0.100 = 0.125.$$

As all the railways do not adopt the maximum superelevation of 150 mm. (6″), we have prepared a diagram representing the thrust in terms of the speed for $h$ = 100 mm. (4″) (fig. 5).

We have also appended the corresponding diagrams of Q in terms of the radius R (figs. 6 and 7).

We have still to decide whether the V to be introduced in the superelevation formulæ represents the maximum authorised speed, or alternatively an average or reduced speed.

The *Belgian Railways* alone explicitely answered this question to the effect

(1) A theoretical case, as 150 mm. (6″) cant cannot be allowed on the straight section tangent to the curve.

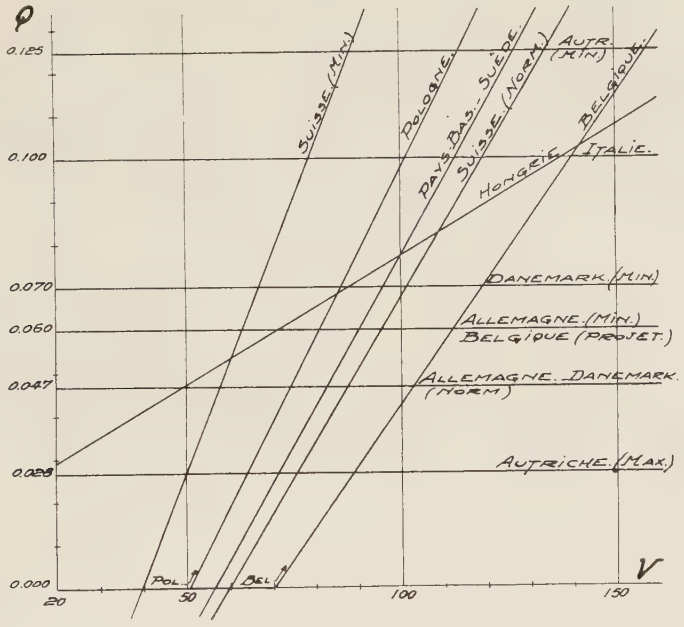



Fig. 4. — Diagram showing the value of the thrust Q in terms of the speed V, for $h$ = 150 mm. (6").

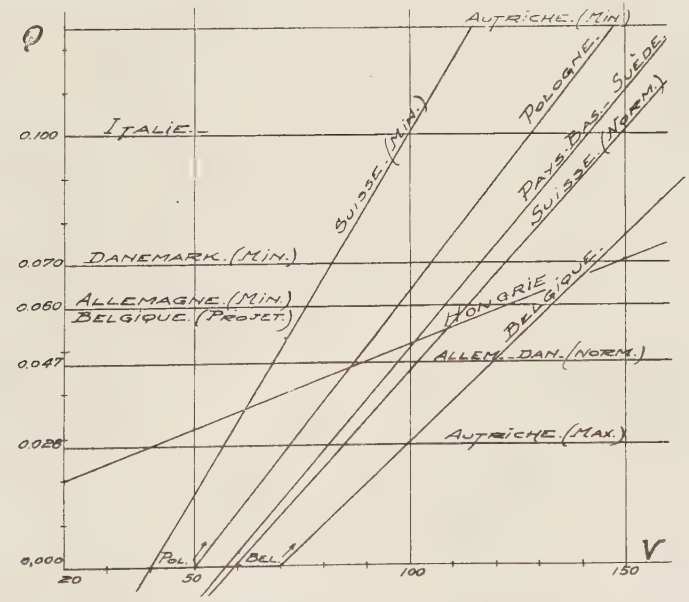



Fig. 5. — Diagram showing the value of the thrust Q in terms of the speed V, for $h$ = 100 mm. (4").

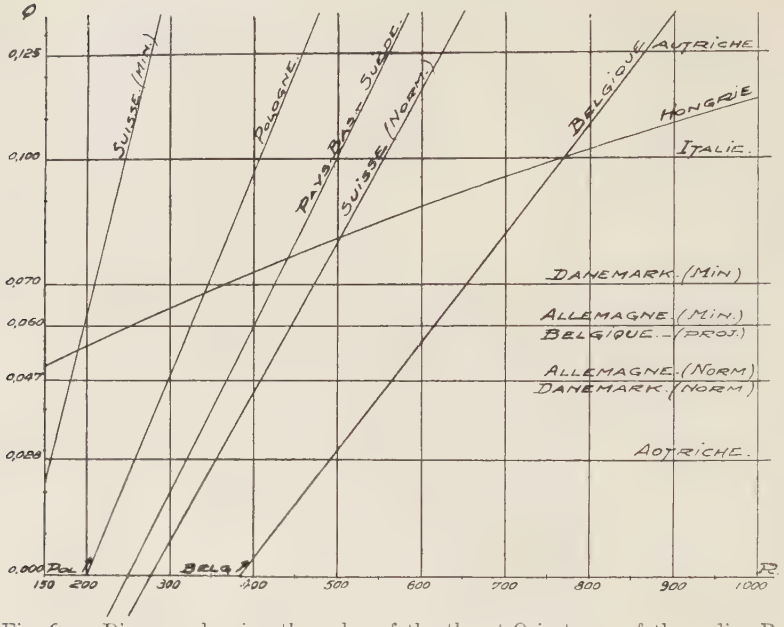



Fig. 6. — Diagram showing the value of the thrust Q in terms of the radius R. for $h$ = 150 mm. (6'').

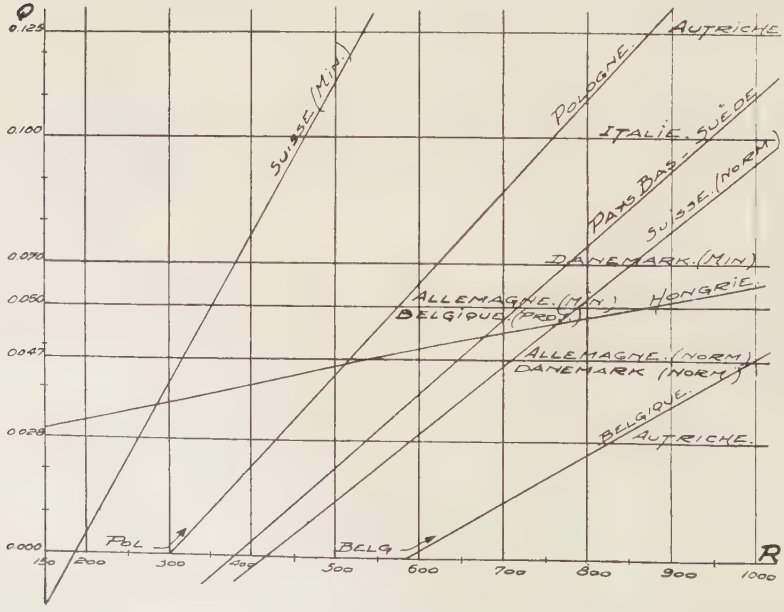



Fig. 7. — Diagram showing the amount of the thrust Q in terms of the radius R, for $h$ = 100 mm. (4'').

that, for low speeds, where they use the formula $h = 11.8\frac{V^2}{R}$, V will be the maximum or practicable speed on the curve considered. The staff, therefore, is allowed to introduce into the formula the actual working speed, which is often lower than the authorised maximum.

As far as the second formula used in Belgium, $h = 825\frac{V}{R}$, is concerned, according to the text of the regulation it is to be considered as a modification of the first, with the object of substituting for the maximum authorised speed V an average speed given by the formula :

$$V_m = \sqrt{70 \, . \, V_{max}}.$$

Following this trend, we come to the conclusion that the railways which prefer the formula $h = 8\frac{V^2}{R}$, V being the maximum speed, base their calculations in fact on the formula with zero thrust (16) but assuming a mean speed

$$V_m = 0.825 \, . \, V_{max}.$$

No better conclusion to all this could be built up, in our opinion, than the proposal of the engineers of the Belgian Railways, resulting from their thorough study of the deliberations of the previous Congress, and supported by data received direct from many Administrations.

Whilst using for the minimum superelevation the formula (18) :

$$h = 11.8\,\frac{V^2}{R} - 90. \quad . \quad . \quad (18)$$

this proposal agrees in a general manner with the formula :

$$h = 11.8\,\frac{V^2}{R} \quad . \quad . \quad . \quad . \quad (16)$$

it being understood that V would be a reasonable average speed, and not one selected arbitrarily, as in the two cases which we have analysed above. This formula would be that suggested in the Japanese report to the Cairo Congress (Question III) and reproduced in the June 1932 *Bulletin,* page 1116.

If the trains running over the curve under consideration be grouped by speeds ($V_1$, $V_2$, . . . . . .) and the number of trains per day in each speed group be $n_1$, $n_2$, . . . . . the average speed is given by

$$V^2_m = \frac{n_1 \, V_1^2 + n_2 \, V_2^2 + \ldots.}{n_1 + n_2 + \ldots.} \quad . \quad . \quad (33)$$

This formula gives greater weight — justified, moreover — to the safety factor (V) which is squared, whilst also taking into account to some extent the wear factor ($n$).

According to this formula, a curve run over by many slow trains and a few fast trains would be given a slight superelevation, though never less than that given by formula (18). On the other hand a curve over which nothing but fast railcars run would be given ample superelevation, as in this case $V_m = V_{max}$ and the equation (16) would be applied without alteration (Recent example : the Brussels-Antwerp electrified line).

* * *

## CHAPTER III.

## Modernising old track for heavy loads and high speeds.

The Railways consulted are unanimous about the methods to be adopted to allow heavy loads to be run over the lines.

These methods consist of :

($a$) replacing, as necessary, the short light rails by heavier and longer ones;

($b$) increasing the number of sleepers;

($c$) improving the joint and the fastenings of the rails to the sleepers;

($d$) improving and, if necessary,

building up the ballast (ramming and rolling are recommended);

(*e*) draining defective formations.

With the object of increasing the authorized speeds over the main or secondary lines, using rolling stock which does not increase the maximum loads carried by the permanent way, the railways recommend in addition to the strengthening of the track :

(*a*) the layout to be improved, by increasing the radii of the curves, even at considerable cost. In mountainous countries such as Switzerland, this solution is however rarely possible financially;

(*b*) the superelevation to be increased;

(*c*) the transition curves to be lengthened, and the superelevation ramps to be reduced;

(*d*) the track to be inspected more frequently and more carefully.

So that vehicles of all types, including the heaviest and most modern engines can be run at higher maximum speeds, i.e. so that the track can stand the most difficult conditions as regards new stresses, all the above methods should be applied simultaneously :

(*a*) Strong track built with rails of about 50 kgr./m. (100.8 lb. per yd.). There is a tendency to use longer rails (from 24 to 30 m.=78′ 9″ to 98′ 5 1/8″); at the joint the sleepers usually either touch or double sleepers are used;

(*b*) As many as 1 815 sleepers per km. (2 920 sleepers per mile) are used *(Belgian Nat. Rys. Co.)*.

On some curves at any rate (of less than 600 m. = 30 chains radius on the Belgian Railways) the sleepers are fitted with metal bearing plates, fastened by separate coach screws, the rails in turn being fastened to the bearing plate by coach screws, bolts or cotters;

(*c*) The ballast consists of gauged broken stone on a solid formation or one, if need be, improved by drainage and a sub-ballast of ashes or gravel. The bridges, if need be, must be strengthened or renewed.

(*d*) The layout is improved and the transition curves are lengthened to provide the proper superelevation, whose rate of development does not exceed if possible 1 in 1 000.

(*e*) The superelevation is increased on these lines to the extent necessary for the passengers' comfort, although it may cause on lines carrying mixed traffic a certain over-stressing of the lower rail on some curves.

On the *Belgian Nat. Rys. Co.* the main lines are checked twice yearly by means of the Hallade apparatus.

Any defects discovered are corrected immediately.

In addition a system of direct inspection of the state of maintenance of all the lines is in operation.

This inspection comprises two stages:

(1) At the beginning of the year the whole of the line is examined in order to ascertain its condition and the extent of the repairs required;

(2) During the summer season, the inspection is continuous and covers the quality of the work done by the gangs. The inspection is facilitated by organising the work of the gangs on the planning system, a schedule being prepared for each gang, district, section, division, and for Headquarters.

The lines of this Company have been classified as follows :

*Important lines.* — Class A : Speed of 120 km. (75 miles) an hour and over, whatever may be the tonnage and axle loads.

Class B : Speed between 90 and 120 km. (56 and 75 miles) an hour.

*Secondary lines.* — Class A : Speed between 70 and 90 km. (43.5 and 56 miles) an hour.

Class B : Speed below 70 km. (43.5 miles) an hour.

The maintenance work is awarded points.

According to the train speeds and the tonnage carried by the line considered, the condition of the line after repair should obtain 13, 14, 15 or 16 out of 20 points, according to its classification.

When the train speeds and the tonnage are raised, the standards of maintenance automatically become more exacting.

The period between systematic repairs and the strength of the gangs are regulated accordingly.

* * *

## PART TWO.

### Facing points which can be taken at high speeds.

One of the principal cares of the Railway Companies at the present time is the attainment of higher and higher commercial speeds. This tendency is general.

In order to achieve these speeds, it is essential that there should be long sections which can be run over without any speed reduction.

On the other hand, local speed restrictions, especially on the high-speed lines, ought to be avoided, not only to reduce the journey time and the working costs, but also to secure greater safety in train running by eliminating the speed restricting signals the drivers have to observe.

The Railway Companies came up against real difficulties when they had to construct points capable of being run over at high speed, on the branch and to determine the rules for laying such points.

The replies given to the questionnaire on this subject enable us to make two observations :

(1) Many railways have not up to the present used points the curved road of which can be taken at high speed.

Only the *Reichsbahn*, the *Belgian, Danish, Dutch, Bergslagen* (Sweden) and *Swiss Federal* Railways use points of this kind.

(2) The first railways to reach high commercial speeds do not as yet use points, the branch line of which can be run over at speeds higher than 120 km. (75 miles).

These railways have had to restore the speed restrictions at junctions when the maximum speeds on the open road exceed 120 km. an hour, even though the points are of modern design.

On principle, if high speeds are to be authorized when branching off, points should be so designed, manufactured and laid that the vehicles run through them and take the branch without shock and without any tendency to overturn.

Consequently the questionnaire sent to the various Railways mainly dealt with the three chief considerations : design, manufacture and laying in the track.

Only six of the Railways covered by our report use points which can be run over to the branch line at high speeds. A resumé of the information obtained on the subject of these points follows.

* * *

### CHAPTER I.

### The lay-out.

Two essential considerations have been examined :

(1) The lay-out proper (geometrical setting out of the routes).

(2) The track gauge of the rails at the different points of the lay-out.

The data collected from the various

Railway Systems are summarised in table 17.

(1) *Lay-out of the curved route.*

We notice that the smallest angle of the tongue with the stock rail is greater than 25′. The smallest, 25′ 5″ 34, is used by the Swedish *Bergslagen* Railway.

It should be noted that if a reduced angle of tongue with stock rail facilitates the vehicles entering the curve, it is on the contrary unfavourable to the lay-out of the branch as it reduces the radius of the latter.

It seems therefore that too small an angle should not be chosen as it has too unfavourable an effect on the radius of the curve between the points and the crossing.

On the other hand, this radius improves if the angle of the crossing is diminished. The common tendency towards the general adoption of small-angle crossings is thus explained.

The smallest angle is that reported by the *Reichsbahn :* 3° 5′ 38″. It corresponds to a tangent of 0.054.

The *Reichsbahn* also reports the greatest radius of curvature (1 200 m. = 60 chains) between the points and the crossing. It should be noted that the lay-out of the two Belgian sets shown in table 17 provide two successive radii of 2 000 and 1 000 m. (100 and 50 chains) respectively close to the point of the blades, and 1 161 and 561 m. (58 and 28 chains) beyond. This arrangement has been used to reduce the unfavourable effect of superposing the angle of the tongue with the stock rail on the curvature of the branch route.

Moreover the Belgian Railways are now designing two new sets of points, a symmetrical double-curve one which can be run over at 120 km. (75 miles) in both directions without any super-elevation having to be provided, the other, simple points deflecting to one side which can be run through at 140 km. (87 miles) when laid in the same way.

The investigations have not been carried far enough for any precise characteristics of the design of these switches to be given.

It is known, however, that these points will be of the « spring » (flexible) type and that the lengths of the blades will be about 14 to 16 m. (45′ 11″ to 52′ 6″). The angle between the tongue and stock rail and the radii will be respectively 15′ — 4 000 and 2 500 m. (200 and 125 chains) — in the symmetrical double-curve switch, and 30′ — 5 000 and 3 500 m. (250 and 175 chains) — in the switch deflecting to one side only.

The use of these switches (with tan 0.054 and 0.03 crossing angles) can only be conceived in the case when both roads cross at different levels by means of a skew bridge. Indeed, the minimum angle in crossings admitted by the Belgian Railways if satisfactory guiding of the wheels through the gaps is to be ensured is 6° 11′ 55″.

The necessity there is to maintain this angle and to also maintain through the crossing a radius of the same value as that found in the switch, would lead to the six-foot way having to be about 17 m. (55′ 9″) wide as regards the switch deflecting to one side.

Contrariwise, in order to maintain a standard six-foot way (2.00 m.) it would be necessary to make use of a tan 0.045 obtuse crossing. Such an obtuse crossing is only practicable if fitted with mobile sections which eliminate completely the gaps in the two roads alternately.

(2) *Track gauge.*

The gauge at points is generally wider than the standard. At the joint before the points of switch blades all the railways maintain the 1.435-m. (4′ 8 1/2″) gauge with the exception of the Swedish and Bergslagen Railways on which it is 1.439 m. (4′ 8 43/64″).

TABLE 17.

## Characteristics of the layout of points which can be run ovre unto the branch line at high speeds.

| ADMINISTRATIONS. | Angle of blade point with the stock rail. | Angle of crossing. | Lay-out of the diverging road : (S.L. = straight section). (R = radius of curve, in metres). | | | Gauge of the track. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | from the point of the blade to the heel. | From the heel of the blade to the crossing. | In the crossing. | At the end of the stock rails on the side of the blade points. | In line with the point of the blade. | | In line with the heel. | | Between the blades and the crossing. | | In the crossing | |
| | | | | | | | In the through road. | In the branch. | In the through road. | In the branch. | In the through road. | In the branch. | In the through road. | In the branch. |
| *Deutsche Reichsbahn* . . . . . | ... | 3° 5' 38'' 60<br>tan. = 0.054 | R = 1 200 | R = 1 200 | R = 1 200 | 1.435 m. | 1.4396 m. | 1.4396 m. | 1.435 m. | 1.435 m. | 1.435 m. | 1.435 m. | [illegible] | [illegible] |
| *Austrian Federal Rys.* . . . . | Have no points that can be taken branching off at high speeds. | | | | | | | | | | | | | |
| *Belgian National Rys. Co.* . . | 30' | 3° 8' 55''<br>tan. = 0.055030<br>4° 29' 34''<br>tan. = 0.07856 | R = (×) 2 000-1 161<br>R = (×) 1 000-561<br>(×) from point of tongue to where in contact with head. | R = 1 161<br>R = 561 | R = 1 161<br>R = 561 | 1.435 m. | 1.435 m. | 1.435 m. | 1.435 m. | 1.435 m. | 1.435 m. | 1.435 m. | 1.435 m. | 1.435 m |
| *Danish State Rys* . . . . . | 27' | 4° 5' 8''<br>tan. = 0.07143 | R = 500 | R = 500 | S.L. | 1.435 m. | 1.445 m. | 1.445 m. | 1.435 m. | 1.435 m. | 1,435 m. | 1.435 m. | 1.435 m. | 1.435 m |
| *Netherlands Rys.* . . . . . | 55' | 3° 48' 50'' 67<br>tan. = 0.0666 | S.L. of 4.750 m. then R = 600 | R = 600 | S.L. | 1.435 m. | 1.440 m. | 1.440 m. | 1.440 m. | 1.440 m. | 1.440 m. | 1.442 m. | 1.435 m. | 1.435 m |
| *State Rys. in the Dutch Indies.* . | Have no points that can be taken branching off at high speeds. | | | | | | | | | | | | | |
| *Hungarian State Rys.* . . . . . | | | | | | | | | | | | | | |
| *Swedish State Rys.* . . . . . | | | | | | | | | | | | | | |
| *Union of Swedish Private Rys.* . | | | | | | | | | | | | | | |
| *Bergslagen Ry. (Sweden)* . . . | 25' 5'' 34 | 4° 24' 10''<br>tan. = 0.077 | R = 450 | R = 450 | S.L. | 1.439 m. | 1.445 m. | 1.445 m. | 1.435 m. | 1.447 m. | 1.435 m. | 1.447 m. | 1 435 m. | 1 435 m. |
| *Swiss Federal Rys.* . . . . . | 28' | 4° 45' 50''<br>tan. = 0.08333 | R = 300 | R = 300 | S.L. | 1.435 m. | 1.447 m. | 1.447 m. | 1.435 m. | 1.452 m. | 1.435 m. | 1.455 m. | 1.435 m. | 1 435 m. |
| *Berne-Loetschberg-Simplon Rys.* . | Have no points that can be taken branching off at high speeds. | | | | | | | | | | | | | |
| *Polish State Rys.* . . . . . | | | | | | | | | | | | | | |

At the points of the switch blades, the width of the track is above 1.435 m. in the switches of all the railways. The only exception is on the *Belgian Nat. Rys. Co.* where the standard gauge (1.435) is maintained throughout the points, on the deflected route as well as on the straight, in view of the big radii used in the layout.

The maximum gauge at the points of switch blades is found in switches on the *Swiss Federal Railways;* it is 1.447 m. (4′ 9″).

As regards the gauge beyond the points of the blades, two rules are observed :

The first consists in gradually restoring the standard gauge immediately beyond the blade points, on both the curved and straight routes. This practice is also followed by the *Reichsbahn* and the *Danish State Railways.*

In the second the widened gauge is maintained nearly up to the crossing on both routes. This is the practice on the *Netherlands Railways.*

In the equipment of the *Bergslagen Railways* and of the *Swiss Federal Railways,* the first rule is applied to the straight route and the second to the deflected one.

The crossings used by all the railways are built to standard gauge (1.435 m. = 4′ 8 1/2″).

* * *

## CHAPTER II.

## Design of points and crossings.

They include four essential details :

(1) the points;

(2) the acute crossing;

(3) the obtuse crossing;

(4) the connecting rails.

The particulars collected on these details are summarised in table 18.

### (1) The points.

The metal of which the switch rails and stock rails are made shows no particular feature to be reported. It is generally of the same quality as the running rails; only the *Reichsbahn* and the *Swiss Federal Railways* heat-treat it.

The stock rails in all cases are machined out of ordinary rails.

Contrariwise, the switch blades are generally machined from rails of special section with a thick web and a heavier foot. The height of this section is usually below that of the ordinary running rail.

Only the *Netherlands Railways* machine the switch blades from rails of ordinary section, but intend to use a heavier section in future.

The switch blades of the *Belgian Nat. Rys. Co.* are made from rails only the web of which has been increased in thickness from 15 to 20 mm. (5/8′ to 13/16″).

It appears interesting to note that on the *Belgian Nat. Rys. Co.* the rails of the running road are canted 1 in 20 to the vertical and that this inclination has also been maintained in points and crossings, except in the switch blades, which have vertical webs. These are somewhat twisted whilst hot, near the heel, which restores the 1 in 20 cant; the points and adjacent rails may thus be connected by standard fish-plates.

The switch blades run over at high speed are generally built in at the heel and they are operated by bending the blades. The only exceptions to be found are on the *Swiss Federal Railways,* and in the case of the latest equipment of the *Reichsbahn,* where the tongues are hinged at the heel.

In switches with heavy tongues built in at the heel, the bending point is localised and this bending is facilitated by reducing the thickness of the web and by cutting away the rail foot near the heel.

In the case of the switches of the *Belgian Nat. Rys. Co.* the foot of the blade is likewise cut away, although in the rail section used only the web was thickened.

The two side faces of the switch blades are planed to an angle with the vertical.

These angles differ materially from one Railway to another.

Between the stock rails and the switch blades there is usually near the blade points a difference in level, the object of which is to keep the load off the planed-down ends of the blades.

This difference in level varies between 14 and 19 mm. (35/64″ and 3/4″) in switches where the points of the blades fit tight against the side face of the stock rail; it reaches 25 mm. (1″) when the point of the blade is housed under the head of the stock rail.

The length of the flexible (spring) blades varies between 12 and 14 m. (39′ 4 1/2″ and 45′ 11″), according to the Railway; tongues of the hinged type are shorter; on the Swiss Federal Railways they are 6.75 m. (22′ 1 3/4″).

Hard-wood sleepers are generally used for supporting switches.

The *Reichsbahn*, however, uses metal sleepers and wood ones. The *Swiss Federal Railways* seem to be the only Administration to use metal sleepers exclusively.

The slide chairs for the switch blades are generally of steel; they are fastened either directly to the sleepers, or through the medium of continuous steel plates located under the blades.

The distance blocks are usually of cast steel. The designer should give them very special attention in view of the important part they have to play.

This consists in maintaining very accurately the distance between the closed tongue and the stock rail and the invariability of the theoretical layout of the blades whilst wheels are running through them.

The section, dimensions, location and the method of fastening down these parts must be studied with the greatest care, in view of the considerable stresses to which they are subjected by heavily loaded wheels travelling at high speed when passing onto the deflected route.

The fixing of the stock rails does not present any particular problem. A bolt passes through the web of the stock rail and secures it to the shoulder of the slide chair.

### (2) The crossings.

Crossings are generally built up from rails.

On the *Danish State Railways*, the *Swiss Federal Railways*, and the *Belgian Nat. Rys. Co.* « monoblock » crossings in cast manganese steel and those built up from rails are used in conjunction.

The *Bergslagen Railway* uses crossings composed of a « monoblock » steel V-piece combined with wing rails made from ordinary rails.

The use of « monoblock » cast steel crossings is to be recommended for lines carrying heavy axle loads at high speed.

The length of the nose of « monoblock » crossings varies according to the angle; it amounts to 8.75 m. (28′ 8 33/64″) in tan 0.054 crossings on the *Belgian Nat. Rys. Co.*

Certain railways using built-up crossings or « monoblock » noses with added wing rails make them as long as 12 m. (39′ 4 1/2″). This practice is adopted probably with the intention of improving the stability of the crossing.

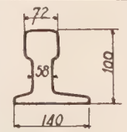
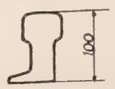
The form and method of fastening the outside check rails of crossings vary from one railway to another.

Generally they are made up of a length of ordinary rail, cranked and secured to the running rail by tie plates and bolts and to the timbers by bearing plates and coach screws.

Thrust plates, arranged on the inside

TABLE 18.

## Design of points and crossings taken at high speeds.

| ADMINISTRATIONS. | Kind of sleepers and fastenings. | Points. | | | | | | | Crossings. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Quality of metal used in the points and crossings. | Rail section from which are planed | | Inclination of the machined faces of the blade to the vertical. | | Type of blade: Articulated or flexible. | Length of the blades. | Monoblock type or built up from rails. | Nature of metal of monoblock points. | Length of the crossing. |
| | | | the blades. | the stock rails. | Inside of the track. | Stock rail side. | | | | | |
| *Deutsche Reichsbahn* . . . . | Wood and steel sleepers. Steel sole plates. | 70, 80 and 90 kgr./mm² Thomas and Siemens-Martin steel heat-treated. | Special section. | Standard rail section. | 1/3 | 1/4 | ... | ... | Built up from rails. | ... | Variable, according to angle. |
| *Austrian Federal Rys.* . | Have no points that can be taken branching off at high speeds. | | | | | | | | | | |
| *Belgian National Rys. Co.* . . | Wood sleepers. Steel sole plates and coach-screws. | Ordinary rail steel not heat-treated. | Rail sections of standard track (50 kgr./m.) but stronger web 20 mm. instead of 15 mm. | Standard. | 1/4 | 2/5 | Flexible. | 14.000 m.<br>12.000 m. | Monoblock. | Cast manganese steel. | 8.75 m.<br>6.00 m. |
| *Danish State Rys.* . . . . . | Pomeranian fir sleepers. Steel sole plates, coach-screws. | 70-80 kgr./mm² Bessemer, Thomas and Siemens-Martin steel not heat-treated. |  | Standard. | 1/5 | 1/3 | Flexible. | 13.200 m. | Built up from rails and monoblock. | Cast manganese steel. | 12.044 m. |
| *Netherlands Rys.* . . . . | Hard wood sleepers, chairs, steel sole plates, coach-screws. | Ordinary rail steel not heat-treated. | Rail sections of standard track. Special section in future. | Standard. | 1/2.5 | 1/4 | Flexible. | 12.000 m. | Built up from rails. | ... | 7.44 m. |
| *State Rys. in the Dutch Indies* | Have no points and crossings which can be taken at high speeds. | | | | | | | | | | |
| *Hungarian State Rys.* . . . | | | | | | | | | | | |
| *Swedish State Rys.* . . . . | | | | | | | | | | | |
| *Union of Swedish Private Rys.* | | | | | | | | | | | |
| *Bergslagen Ry. (Sweden)* . . | Wood sleepers. | ... |  | Standard rail section. | ... | ... | Flexible. | 13.200 m. | Cast nose; wing rail from standard rail. | ... | 12.355 m. |
| *Swiss Federal Rys.* . . . . | Metal sleepers, clips, hook bolts, hard wood, sole plates, coach-screws or spikes. | 70-kgr./mm² steel heat-treated. | Special section. | Standard. | 1/3<br>1/4 | 1/2.06 | Articulated. | 6.750 m. | Monoblock.<br>Built up. | Cast manganese steel | 3.120 m. |
| *Berne-Loetschberg-Simplon Rys.* | Have no points which can be taken at high speeds. | | | | | | | | | | |
| *Polish State Rys.* . . . . | | | | | | | | | | | |

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and the outside of the check rail on each sleeper, help to maintain the gauge accurately at the crossing on the *Belgian Nat. Rys. Co.*

### (3) Obtuse crossings.

We have not received any information about the obtuse crossings used on foreign lines.

We will therefore limit ourselves to mentioning that on the *Belgian Nat. Rys. Co.* « monoblock » obtuse crossings of cast manganese steel are used in conjunction with those built up of rails, and that the minimum angle which ensures a satisfactory guiding of the wheels over the gaps of the crossing is fixed at 6° 11′ 55″.

In addition, in view of the tendency to generalise the use of the bogie, it should be noted that in the flattest obtuse crossings or those nearly so, the wheels cannot be prevented from coming into contact with the V-pieces of the crossings in certain unfavourable cases of short wheel-base vehicles running out of square.

Whilst there is no risk of the vehicle trying to take the two roads, the position of the axle has to be centered by the V-piece. This imposes a considerable strain on the latter when the train is travelling at high speed.

It is possible to reduce the risks of contact between the wheel and the V-pieces of crossings, and to diminish the severity of the stress when contact does occur, by providing the V-pieces with extended check rails. These have the effect of leading vehicles with short wheelbase into a position more nearly parallel to the centre line of the track at the moment when the axles reach the V-pieces and of ensuring the retention of this favourable position whilst the gaps are being traversed.

### (4) Connecting rails.

Connecting rails have everywhere the same section as those used in the running road.

The Railways generally arrange the joints between the connecting rails, the switch, the crossing and the obtuse crossing in such a manner as to allow free expansion.

Only the *Reichsbahn* and the *Belgian Nat. Rys. Co.* consider the points and crossings as a single unit, whose variations in length are carried through to the ends. According to this conception these Railways eliminate all play at the joints separating the connecting rails from the switch, from the acute crossing and from the obtuse crossing.

On the *Belgian Nat. Rys. Co.* this arrangement has been in operation for several years without any drawback. It would even appear that welded joints might be tried. Welding would do away with all breaks in the running surface and ipso facto with the blows from wheels, and all their consequences.

As regards welding, from the information sent in, the conclusion must be reached that it is hardly used at all in points and crossings.

We have not received any description of any application of welding into one unit the constituent parts of points and crossings. Several trials have been made recently to build up worn parts by adding new welding metal to cracked, worn or crushed parts on the *Belgian Nat. Rys. Co.*, as mentioned above.

The connecting rails are fixed on the sleepers and joined up, at the switch, at the acute crossing and at the obtuse crossing by means of fastenings and fish-plates of the type used on the running road.

The use of cast steel is general for all the details of points and crossings intended for high-speed running, such as chairs, tie plates, thrust pieces, housings, etc.

* * *

CHAPTER III.

## Conditions under which points and crossings are laid and run over.

The particulars which we have obtained in connection with the laying of points and crossings and running over them at high speed are given in Table 19.

The tan 0.054 (1 in 18.52) crossings of the *Reichsbahn* (the minimum angle) have an overall length of 64.817 m. (212′ 8″).

Those of the *Belgian Nat. Rys. Co.* come next in order; they are tan 0.055 (1 in 18.18) and their length is 57.833 m. (189′ 8 25/32″).

The other railways do not go beyond tan 0.07 (1 in 14.3) crossings. The length does not appreciably exceed 40 m. (131′ 2 3/4″).

The majority of the Railways consulted put in points and crossings on curves and with superelevation.

The conditions governing the laying with superelevation, and the amount of superelevation are fixed according to the particular regulations of each Railway.

The *Reichsbahn* calculates the superelevation by means of the rules in use for the running road.

On the *Belgian Nat. Rys. Co.* the upper limit of the superelevation is fixed at 60 mm. (2 3/8″) when the through road is on the straight, and at 90 mm. (3 9/16″) when laid on a curve. The radius of the through road is taken into consideration in every case when finding the value of the superelevation.

The *Danish Railways* do not seem to follow any precise rules for calculating the superelevation, this being adapted to local conditions.

Finally, the *Swiss Federal Railways* give the connection a superelevation of two-thirds of that permitted in the running road on curves of the same radius.

Table 19 also shows the maximum speeds authorised over points and crossings by the railways, both when they are laid on the straight and on curves.

On the *Reichsbahn* the maximum speed authorised unto the branch is fixed in every case by the formula given in Table 19.

When the through road is straight, the application of this formula allows a maximum speed of 100 km. (62 miles) if the points and crossings are located without cant on a curve of 1 200 m. (60 chains) radius at least, and a speed of 120 km. (75 miles) if there is cant, provided that its value reaches 50 to 60 mm. (2″ to 2 3/8″).

When points and crossings are laid on a curve, the authorised speed is given by the same formula, in which R is the least radius if the two tracks are convergent, and the radius of the more important track if the roads are divergent.

On the *Belgian Nat. Rys. Co.* tan 0.055 and 0.0786 (1 in 18.18 and 1 in 12.74) crossings, with the through road on the straight can be traversed respectively at 90 and 60 km. (56 and 37.3 miles) on the deflected road when there is no cant.

These speeds are increased to 120 and 80 km. (75 and 50 miles) if a cant of 60 mm. (2 3/8″) is provided.

When the points and crossings are laid on a curve, the speed is fixed in terms of the radius of the through road; if the roads are divergent, the maximum authorised speed is restricted to 20 km. (12.4 miles) on the road having negative cant.

On the other Railways tan 0.065 (1 in 15.38) is the limit with the result that the radius of the curved route is relatively small. The authorised speeds vary between 60 and 75 km. (37.3 and 46.6 miles) according to the railway, if the through road is on the straight.

When laid on a curve, the rules relating to the running road are generally applied.

TABLE 19.

## Maximum speeds points and crossings can be run over according to the way they are laid.

| ADMINISTRATIONS. | Type of points and crossings and year first of this type were laid. | Total length as laid. | Maximum speeds allowed running unto the branch line. | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | the through road being on the straight. | | | the through road being on a curve. | | |
| | | | points level. km./h | points laid with cant. amount of cant. | points laid with cant. speed. | direction of diverging road. | the points being level. | the points being laid with cant. |
| *Deutsche Reichsbahn* . . . . | tan = 0.054 (1914) | 64.817 m. | 100 | Variable. | $V = \sqrt{\frac{L + 90}{11.8} \times R}$ L = cant. | $V = \sqrt{\frac{h + 90}{11.8} \times R}$ Converging junction : $h$ is fixed according to minimum R. Diverging junction : $h$ is fixed in terms of R of most important track. | | |
| *Austrian Federal Rys.* . . . . | Have no points that can be taken branching off at high speeds. | | | | | | | |
| *Belgian National Rys. Co.* . . | tan. = 0.055 (1931)<br>tan. = 0.0786 (1930) | 57.833 m.<br>43.057 m. | 90<br>60 | 60 mm. | 120 km./h.<br>80 km./h. | Speed fixed to suit radius. | | |
| *Danish State Rys.* . . . . . | tan. = 0.07143 (1923) | 41.018 m. | Maximum speed fixed according to rules in force for the speed o curves provided with a given superelevation. | | | | | |
| *Netherlands Rys.* . . . . . | tan. = 0.0666 (1906) | 42.025 m. | 75 | Speed fixed in relation with radius of curve. | | | | |
| *State Rys. in the Dutch Indies.*<br>*Hungarian State Rys.* . . .<br>*Swedish State Rys.* . . . .<br>*Union of Swedish Private Rys.* | Have no points that can be taken branching off at high speeds. | | | | | | | |
| *Bergslagern Ry. (Sweden)* . . | tan. = 0.077 (1932) | 41.398 m. | 75 | ... | ... | No curved through road. | | |
| *Swiss Federal Rys.* . . . . . | tan. = 0.08333 (1929) | 33.818 m. | 60 | ... | ... | ... | ... | Cant = 2/3 of cant fixed for standard track. |
| *Berne-Loetschberg-Simplon Rys.*<br>*Polish State Rys.* . . . . . | Have no points that can be taken branching off at high speeds. | | | | | | | |

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With the exception of the *Netherlands Railways*, on which investigations are being made, the Railways consulted do not anticipate that the maximum speeds in force at the present time for traversing points and crossings are likely to be increased.

### General safety mesures.

Strict safety measures ought to be taken when high-speed running occurs over the tongue in the facing direction.

The safety devices adopted by the various railways bear great resemblance to one another in principle.

Their object is to prevent the switches moving, by means of a lock, and to control the position of the lock as well as that of the tongue, to ensure they take up a position agreeing as nearly as possible with the theoretical one.

The control is generally imperative and permanent whilst the train is passing.

The points are operated either mechanically or electrically.

On the *Belgian Nat. Rys. Co.*, whatever may be the method of operation, the tongues are connected up at two places, at the point and at a place midway between the point and the heel; they are in addition connected by tie rods which cause them to move together throughout their length.

Such an arrangement is necessary to ensure the tongues being in their proper position in spite of their great flexibility.

As to the safety devices (bolt-detection), they are only used at the point of the blades.

* * *

## SUMMARY AND CONCLUSIONS.

PART ONE.

## The construction of modern track to carry heavy loads at high speeds and methods of modernising old track for such loads and speeds.

CHAPTER I.

### Characteristics of present-day vehicles.

I. The axle load usually does not exceed 20 t. (19.7 Engl. tons). The *Reichsbahn* limits the tonnage to this figure for all new vehicles to be built; the *Hungarian State Railways* who have not at the present time axle loads over 18.5 t. (18.2 Engl. tons), are of the opinion that it would be desirable to raise to 25 t. (24.6 Engl. tons) the maximum axle load of electric locomotives.

The *Belgian National Railways Company* already possesses many steam locomotives with maximum axle loads of between 22.6 and 24 t. (22.3 and 23.6 Engl. tons).

II. The stress caused in the track is increased as a result of : the forces transmitted to the wheels by the power units, the inertia force of the moving parts connected to the wheels, the unevenness however small, of the track, the unequal distribution of the weight of an axle between its two wheels, and the sudden application of the loads by trains running at speed.

It would be of considerable interest to carry out systematic measurements of the stresses developed in the track under various conditions of loading.

III. High speeds must be attained, conditions as regards safety and comfort, being maintained, and even improved.

The increased loads and speeds ought to be made good by a corresponding improvement in the strength of the track, which cannot be obtained without increasing its rigidity. The rolling stock, therefore, must be very flexible so that it can easily negotiate curves and be

very stable in spite of its increased dimensions and weight.

To meet these requirements :

— The lay-out of the track must be improved, development of the curvature and of the superelevation in curves must be progressive, the permanent way must be strengthened and very carefully maintained.

— As regards the rolling stock : means facilitating curve negotiation by the rolling stock must be perfected; investigations into the best tyre contour relatively to the rail section should be continued, the spring gear of the vehicles should be improved, and the interior lay-out made more comfortable.

IV. As regards the results obtained so far in the matter of speed, we believe that on the railways on which high speeds have been run regularly for many years, the 120-140 km. (75-87 miles) an hour stage is passed today in several particular instances, and that its extension is more a matter of available motive power than a track problem.

Henceforth the tendency will be towards the attainement of the 160 km. (100 miles) an hour speed, which the motor trains having large excess power will reach easily enough.

In the case of steam traction and electric traction on the third rail, new types of power units will probably have to be designed as a preliminary step. Generally speaking we are of the opinion that the permanent way of the main lines as well as the coaches using them are already suitable for such high speeds, provided that some little weak points are made good.

## CHAPTER II.

### Present-day main-line permanent way.

V. Most of the railways have followed the general recommendations on the resistance of rails to breaking and to wear, made at the Madrid Congress, in 1930.

In spite of the improvements in the manufacture of rails, the more exacting specifications and the reduced rolling tolerances, and in view of the future increases in axle loads and train speeds, it would be useful to study, in cooperation with the metallurgists, the phenomena of work-hardening of the rail metal, by the most modern methods of investigation in connection with changes in the internal structure of the metal, in particularly by the X-ray process.

VI. Heat treatment of the whole rail — for use on sharp curves — or of the ends only is favoured by several Railways.

Rails of special steels, of hard high-carbon Siemens-Martin or electric steel, having a tensile strength exceeding 80 kgr. (50.8 lb. per sq. in.), or hard electric steels containing 1.6 to 1.9 % of manganese, and « compound » rails are being tested on various Railways.

Rails with 0.4 to 0.6 % of copper are being used in tunnels to reduce oxidation.

VII. The weight of rails does not exceed 50 kgr. (100.8 lb. per yd.) on the Railways covered by this report. The advocates of heavier rails are not many in Europe. The Railways prefer to strengthen the track by reducing the intervals between sleepers.

VIII. A rational rail renewal policy based upon a comprehensive study of the renewal frequency on the various sections of the lines in terms of the tonnage carried and of the ruling speed will prove advantageous.

Such a policy rapidly improves the general condition of the lines and obviates the risk of untimely expenditure.

IX. The joint is the weak point in the track; it is therefore beneficial to reduce the number. Welding the rails in the shops and on the site is therefore a question of first importance. Experience seems to prove that there is less risk in welding all the rails, provided that they are laid at a temperature of

about 30° C. (86° F.) than in using very long rails, e.g. over 60 m. (196′ 10″) long because of the risk of the joints closing, through creep at low temperatures, due to the track being divided into lengths.

X. Increasing the number of sleepers is justified by the increasing axle weights and train speeds, and by the advantage to be derived from a reduction in the costs of track maintenance.

The timber sleeper is the one which most readily lends itself to high-speed running.

XI. The fastening of the rails to the sleepers must satisfy the following conditions :

(1) when tightened down, prevent the rail foot from damaging the top of the sleepers, whilst retaining some elasticity;

(2) maintain the correct gauge and prevent any lateral slip or canting of the rails through the thrust of the wheel flanges;

(3) prevent the rails from creeping on the sleepers.

Laying the rails directly on the sleepers, a method resorted to in Holland, where it is called the « Est » method, and also in Belgium, gives good results in straight roads and large-radius curves provided that the rail foot is wide.

Laying the rails on metal bearing plates with fastenings independent from those holding the bearing plates to the sleepers appears to be essential on main lines carrying very fast traffic and laid with *long rails*.

The fastenings of the rails to the bearing plates must satisfy the following conditions :

(1) they must be able to be strongly tightened up and remain so in order to absolutely prevent the rails sliding on the sleepers;

(2) they must have some elastic detail in order to damp the effects of the stresses developed in the track;

(3) it must be possible at any time, even after a number of years, to restore the fastenings to the as new condition, either by taking up wear or by renewing part or all of the component parts.

Metal bearing plates must be used on sharp curves — less than 600 m. (30 chains) radius — when the other sections of the track are laid without bearing plates.

XII. The increase in loads and speeds calls for a thicker layer of ballast between the sleepers and the formation, so as to better distribute the loads transmitted by the track.

Hard broken stone is used almost exclusively on the main lines, the size being generally between 30 and 70 mm. (1 3/16″ and 2 3/4″).

It must be neither friable, frost-cleft, nor spongy.

It is desirable to test the ballast for size and resistance to impact before accepting it.

Preliminary ramming or rolling of the ballast is recommendable, when a new track is being laid or when an old one is being wholly renewed.

Small ballast, 5 to 25 mm. (3/16″ to 1″) in size is suitable for shovel packing.

XIII. The formation and the bridges which form the foundation of the track must be strong enough to resist permanently the loads, thrusts and blows acting directly or through the medium of the ballast.

The formation, when necessary, must be improved by drainage, or when the ground is bad, by covering it with a blanket of clinker or of screened cinders before ballasting.

Bridges and other structures ought to be inspected and checked by means of stress calculations, direct measurements, and tests when the loads on them are increased; they should be strengthened if necessary.

From this point of view experiments should be made to determine exactly the magnitude of the stresses actually borne

by the various members or parts of bridges, in order to establish how far they are directly influenced by the speed.

XIV. In order to reduce the lateral movements of the vehicles, all research work should be directed towards the reduction of the play between the guiding surfaces of rail and wheel. This problem is entirely a matter of rolling stock design; when vehicles of all kinds will negotiate curves with the same flexibility as bogie vehicles, there will no longer be any obstacle to the elimination of gauge widening in most of the curves on running roads. Improved guiding of the wheels would be obtained, hunting would be reduced, side wear of the outer rails and the wheel flanges would be diminished in large measure.

XV. The most important thing to be done to obtain safe, smooth, and comfortable running at very high speed is geometrical perfection, in plan and cross section, of each line of rails on straight alignments and perfect regularity on curves.

Correct laying on the straight depends on the strength of the equipment and the care expended upon its maintenance. The present-day materials and improved maintenance methods taken together seem to meet the requirements of modern operation.

The regularity of the curves depends upon the same factors, and certain further precautions. As the joints have a tendency to develop, in plan, sometimes angular points and sometimes flats, depending upon the relative rigidity of the fishing, railway operation will gain much by the use of long, even welded, rails. Then too, the level of the rails relatively to one another is of even greater importance than perfect straightness, and should be watched all the time.

There is a great advantage in using large-radius curves (some 2 000 m. = 100 chains at the least); however, the existing location of the lines and the crowded areas surrounding them frequently prevent the curves being improved as desired. Insufficient radius can nonetheless be made good by giving superelevation.

We have shown how the regulations on this subject differ from one System to another; this means that the value of the superelevation may vary, without harmful effect, between fairly large limits. But two important factors dominate here : the necessity of maintaining absolutely constant uniformity of the superelevation throughout the curve, as well as developing the superelevation very gradually. In the text of the present report, we have indicated and explained the formulæ we think we may recommend, and which enable the superelevation to be calculated in the most rational manner, taking into account the speed to be authorised, and the maximum speed sanctioned, expressed in terms of the superelevation.

## CHAPTER III.

### Modernising old track for heavy loads and high speeds.

XVI. The methods to be used for modernising old track consists, from the point of view of the loads to be carried, in :

(*a*) replacing when required short light rails by heavier and longer ones;

(*b*) strengthening the sleepering;

(*c*) improving the joints and the rail fastenings;

(*d*) improving and possibly strengthening the ballast (ramming and rolling are recommended);

(*e*) draining defective formation.

From the point of view of operating speeds, it is desirable :

— to improve the layout by increas-

ing the radii of the curves and the amount of superelevation;

— to lengthen the transition curves, to flatten the cant developing gradients, and to inspect the track frequently and rigorously.

PART TWO.

## Facing points which can be taken at high speeds.

XVII. The attainment of high commercial speeds necessitates trains with heavier and heavier axle loads, drawn by engines of ever increasing power, running over points and crossings at higher and higher speeds.

The complex problems arising therefrom tend, in particular, to improve the layout of points and crossings and to add to their solidity. Many such problems have engaged the attention of all Railway Administrations, especially in recent years.

The particulars we have obtained in response to the enquiries we made, and which are summarised above, have enabled us to derive certain general principles :

XVIII. The layout and the design of points and crossings should be of such a nature that the vehicles run smoothly over them.

For this purpose :

(1) The radii of curves ought to be as large as possible, which necessitates the use of a crossing having the least angle of opening;

(2) A transition should be provided between the curved and straight parts;

(3) The angle of deviation of the switch tongues, the continued use of which appears inevitable, ought to be reduced to a minimum;

(4) Any gaps in the running surfaces ought to be avoided, which implies, for example, the building-in of the heels of the tongues, the elimination of play at joints between the parts of the points and crossing, and even the welding together of these parts;

(5) The vehicles must be guided continuously; for this purpose an attempt should be made to abolish all gauge widening not essential to allow the vehicles to negotiate the curve;

(6) Bolted assemblies are not rigid enough and should not be used.

Welded crossings would be an appreciable improvement, if soundness could be guaranteed.

The use of cast steel « monoblock » crossings is to be recommended.

(7) The method of fastening the points and crossings to the sleepers ought to be sturdy and maintain the various component parts strictly in their correct position.

XIX. Points and crossings should be laid as far as possible under the same conditions as the running road, over which the trains travel under satisfactory conditions of safety and comfort.

To this end, it is necessary that :

(1) The curved parts of a switch should be provided with superelevation in proportion to the curvature.

Experience has shown that it is good practice to provide superelevation in the straight route of a switch so as to be able to give cant to the curved route.

(2) The transitions between the level parts and the canted parts should be developed by an easy and constant progression.

The maximum speeds for running over points and crossings should be as high as possible, but should nevertheless be calculated with care.

Well defined rules for determining the maximum permissible speed, in terms of the lay-out and the laying conditions, should be got out, which should, however, be checked by experience before their general adoption is authorised.

[ 385. 57 ]

# INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

13th SESSION (PARIS, 1937).

## QUESTION XI :

# Selection, orientation and instruction of railway staff.

## REPORT

*(Czechoslovakia, France and Colonies, Belgium and Colony, Luxemburg, Switzerland, Austria, Hungary, Jugoslavia, Bulgaria, Rumania, Greece, Turkey),*

by J. HONDL,

Manager of the Staff Office at the Ministry of Railways, Czeckoslovakia.

### Psychotechnical examinations.

#### History.

Though psychotechnics now play an important part in economics, their object is not always fully understood and clearly defined.

To make the economic and social importance of psychotechnics clearer, it would be as well to give a historical review of the beginnings of this science.

Psychotechnics form a definite branch of practical psychology. Mr. H. MÜNSTERBERG, Professor of psychology at Harvard University, who was the first to write a systematic thesis on psychotechnics (in 1924) gave the name « psychotechnics » to all branches of practical psychology resulting from the application of psychology to the different factors of which our culture is composed, and especially to the elements of the Community — social psychology; to human health — psycho-therapy and psychoanalysis; to economics, education, etc.

To-day psychotechnics are only one branch of practical psychology, which deals not only with technical problems, i.e. problems of production from the point of view of the human factor, but with the psychology of all labour, of all human activity, and of all tasks performed by mankind in general.

In this sense psychotechnics can be called economic psychology, its principal problem being that of work.

In actual fact, each task includes a whole series of psychological problems, seeing that those who work and create

*Bibliography :* « Encyklopedia vykonnosti » svaz. I — CLOVEK — Praha nakl. Sfinx — 1934 (Encyclopedia of efficiency, vol. I — Man — Prague, Sfinx, Editor; 1934) Proceedings of the VIIIth International Conference on Psychotechnics held at Prague in 1934 — Prague — Orbis, 1935; « La selection professionnelle au moyen de la psychotechnique. Son application sur le réseau du Nord français » (Vocational selection by means of psychotechnics, their application on the French Nord Railway). Report by Messrs. LE BESNERAIS, Ingénieur en chef de l'Exploitation, French Nord Railway and BONDON, Ingénieur divisionaire du Service Central de l'Exploitation, Nord Railway — Paris, 1933.

new values are individuals who think, feel, and act. Aptitude for a given kind of work is not in itself sufficient; to be able to do the work well, workers must be psychologically educated, in view of their professional improvement, the whole organisation of the work to be done having to be adapted to the psychological nature of the man.

This point of view was adopted long before the Great War, by W. TAYLOR.

Since 1918, psychotechnics have been very closely connected with the whole scientific movement generally known as the « Scientific organisation of work », but it always has brought out the importance of the human factor very clearly.

In his book « The Psychology of Management », Frank GILBRETH, Taylor's pupil and successor, says that the decisive factor in the successful management of an undertaking is not the work alone, but the worker; and V. B. CORNELL, Professor at New York University, states in his book « Principles of industrial organisation and the management of business undertakings » that : « the best technique, the most precise methods of production and the best mechanical apparatus will be useless if there are no suitable workers devoted to the undertaking ».

Dr. F. SERACKY, Head of the Central Psychotechnical Institute of Prague, in his treatise on the modern rationalisation of work from the psychotechnical point of view, recommends every important undertaking to set up a special section of employees responsible for carrying out the following duties :

(1) Allocation of the employees according to their aptitude for given duties;

(2) Introducing and keeping individual records for each worker, showing the work done by him and his individual development.

It is also necessary to watch in his practical work the worker who has passed the psychotechnical examination exceptionally well, well, or less well.

(3) Carry out investigations into individual working conditions which facilitate the work or make it harder — this with particular reference to the health of the worker and his social and home life.

(4) Investigations into the actual working conditions — particularly as regards hours of work and the rate of working, in order to rationalise the working methods.

(5) Education of the workers based on their intelligence and character (control of the work done and work programmes).

(6) Professional improvement of the workers for the different kinds of work by applying psychotechnical methods.

(7) Moral and physical welfare of the workers (hygiene, food at reduced prices, housing, etc.).

It appears advisable to apply similar principles to the railways.

*The necessity of selecting the operating staff by psychotechnical methods* arose recently through the growth in traffic and the increase in accidents on the railways. It is interesting to note that psychotechnical methods were used first of all on tramways. For example, in 1910, Mr. H. MÜNSTERBERG, whom we mentioned above, first applied psychotechnical methods in America when selecting tram conductors; later on, in 1917, this question was studied in Germany by Mr. W. STERN, who built a special instrument for recording alertness and speed of reaction. The first psychotechnical examination system was drawn up in 1919 by Mr. K. TRAMM for the Berlin Metropolitan Railway. In this system, an examination was made of the sight, hearing, memory, attention, actually the reaction to visual, auditory, or motorial disturbance, and finally of

technical knowledge, ability, and physical strength.

In France, Mr. J. M. Lahy drew up a special method for examining tram conductors; the need for a psychotechnical examination for tram conductors was also recognised in Russia, particularly in Moscow. Similar psychotechnical examinations for omnibus drivers were introduced in several European and American States.

In the case of railway services, psychotechnical examinations were introduced in Europe for the first time in 1917 for locomotive drivers, on the initiative of Dr. Ulbricht, President of the German State Railways Division at Dresden, where the first psychotechnical laboratory was built. As time went on, the need for psychotechnical examinations for other branches of railway work, both executive and administrative, was gradually recognised, and perfect systems of psychotechnical examinations with the corresponding laboratories have been set up on many European and non-European railways.

The question of the theoretical and practical application of psychotechnics to the transport industry, and in particular to the railways, is being studied with great interest on a purely scientific basis. The same question is also being dealt with at the International Psychotechnical Congress. Thus, for example, at the 8th Meeting of the Congress, held at Prague (11-15 September 1934), a series of extremely interesting lectures were given, which were published in 1935 in the Congress Proceedings. Mention may be made of the most interesting, i.e. those of :

Messrs Lahy & S. Korngold : Experimental research into the psychological causes of accidents at work. Professional selection of pointsmen;

J. Wojciechowski : The psychic attitude of the Polish railway officials during psychotechnical investigations;

J. Drabs : New researches into the aptitude of the drivers of fast vehicles;

S. Korngold : The part played by intelligence in professional work.

After these few general remarks on the importance of psychotechnics as applied to the selection of candidates for railway work, I now go on to Question XI entitled :

« *Selection, orientation and instruction of railway staff.* »

Our report on these important problems covers the following countries : Austria, Belgium and Colony, Bulgaria, France (Protectorates and Colonies), Greece, Hungary, Luxemburg, Rumania, Switzerland, Czechoslovakia, Turkey and Jugoslavia.

Replies to the questionnaire addressed to 63 Railway Administrations operating 141 759 km. (88 087 miles) of line were received from 47 Administrations with a total length of lines in operation at the end of 1935 of 133 344 km. (82 858 miles) ; 16 railway administrations with a total length of 8 415 km. (5 229 miles) of lines in operation did not answer the questionnaire.

Out of the 47 administrations replying to the questionnaire, only one third, i.e. 16 Administrations sent in more or less detailed answers, in accordance with the three chief parts of the question : selection — orientation — instruction of railway staff.

From the replies received it appears that *psychotechnical methods for the selection of staff* are only used at present by 12 Railway Administrations (with a total length of line in operation of 73 839 km. (45 882 miles) at the end of 1935) ; one Administration (*Bulgarian State*) is studying this question, while other Railway Administrations (with a total length of line in operation of 65 125 km. = 40 467 miles) replied in the negative, explaining that they did not use psychotechnical methods either

on account of the smallness of their system, or because of the excessive cost of such methods.

*Switzerland* (*Federal Railways* and the *Bernese Alps Railway*) heads the list, having introduced in 1923 obligatory psychotechnical examinations for the selection of the shop staff; — *Czechoslovakia* (*State Rys.*) also introduced such examinations in 1923; then come : *Austria* (*Federal* Railways) in 1924; — *Jugoslavia* (*State Rys.*) in 1926; — *France* (*Nord*) in 1933; (*Compagnie des Tramways de l'Ain*) in 1934; (*State*) in 1934; (*Paris-Lyon-Mediterranée*) in 1935; — *Rumania* (*State*) in 1936. The *Royal Hungarian State Rys.* stated that psychotechnical methods have been used for the selection of certain grades for some years, but did not say when such methods were first introduced.

Psychotechnical laboratories exist in : *Austria* (1); *France : Nord* (1), *Tramways de l'Ain* (1), *State* (1); *Switzerland;* (*Federal Railways*) one fixed laboratory and two travelling laboratories; in *Jugoslavia* (1); the *Czechoslovak State Rys.* have made an agreement with the Central Psychotechnical Institute, of Prague, whereby they can use this Institute's laboratory. The *French Est Rys.* use the laboratory belonging to the *French Nord* Railways. The Paris-Lyon-Méditerranée uses the French State Rys.' laboratory. As regards the design and equipment of the psychotechnical laboratories, that belonging to the *French Nord* Railway must be mentioned first of all, as not only is it exceptionally well looked after, but considerable capital has been invested in it. It should be stated, however, that as far as can be seen from the replies received, all the laboratories mentioned above are modern and satisfactory.

All the Railway Administrations applying psychotechnical methods are satisfied with the results obtained and stress the fact that psychotechnical examinations on aptitude (Eignungs-Prüfung) in connection with the general knowledge examination (Kenntnisprüfung) and the medical examination of candidates for railway service are undoubtedly the best way of eliminating unsuitable candidates, and consequently are very important for the selection and training of the railway staff.

This statement is also proved by the very favourable coefficient of correlation, as the results of the psychotechnical examinations agree from 70 to 90 % with the results of the practical examinations subsequently passed by the railway staff in the different branches of the service.

The extent and method of carrying out the psychotechnical examinations are far from uniform. It may be stated, however, that the classes of staff bound to pass a psychotechnical examination before admission are always being extended, and today include staff in the shops, traffic, operating and commercial, engineering and maintenance services, and recently the administrative services as well.

In spite of all the results obtained — which taken as a whole are very satisfactory — through applying psychotechnical methods in railway service, there are still many large railways who have not yet introduced psychotechnical examinations in connection with the selection of their staff, and have not explained their reasons in their replies. These railways include, for example, the *Belgian National Rys. Co.*, the *Alsace-Lorraine Rys.*, and the *Paris Orléans-Midi Rys.*

As regards questions in connection with the *professional guidance* of the staff, no railway answered in the affirmative.

As for the last part of Question XI, i.e. the *instruction of the staff,* replies were received from 14 Railway Administrations representing a total length of line of 80 466 km. (50 000 miles) with a total staff of 780 000. Particular men-

tion may be made of the reports on the actual position of the schools and professional railway courses, sent by the following Administrations :

Belgium (*Belgian Nat. Rys. Co.*); France (*all the main-line Railways*); Switzerland (*Federal Rys.*); and Czechoslovakia (*State Rys.*), the latter's very detailed report deserving special attention.

From the replies received it may be noted with satisfaction that special attention has been paid to this important question of staff instruction, as it is indisputable that the prosperity of a railway depends not only on the very careful selection of the proper staff, but also on the young candidates for railway service being suitably and efficiently educated.

The cost of such instruction, often very high, it is true, is not unproductive; on the contrary, it undoubtedly contributes, particularly in the present world economic crisis, and to a large extent, to help the railways in their competition with ever growing road traffic and air traffic, by providing it with staff which, from both the technical and working points of view are thoroughly instructed and have a sound knowledge of the duties they have to fulfil in the best interests of the undertaking which employs them.

At this point, I would like to recall the names of Messrs Mereutza, Barth, L. C. Fritch, and Dr. B. Schwarze, who, at the Madrid Railway Congress in 1930, presented very interesting reports on the question on the agenda of that Session : « Methods to be followed in training of staff, professional, technical and ordinary working grades ». (See *Bulletin of the International Railway Congress Association,* August 1929, p. 1453; September 1929, p. 1905; August 1929, p. 1315; April 1930, p. 1197, and May 1930, p. 1526.)

* * *

As mentioned above, certain Railways sent in very detailed and thorough replies to the Questionnaire on Question XI. As it is impossible to give these replies in extenso — instructive and important as they are — the essential details have been summarised below. These are the replies from the following Railway Administrations :

**AUSTRIA. — Austrian Federal Railways.**

Length of lines in operation at the end of 1935 : 5 796 km. (3 602 miles).

Yearly (*average*) strength of staff : 55 899 employees, including 3 273 so called « auxiliary » employees.

*General and historical information.*

Psychotechnical tests when engaging workshop staff were introduced by Mr. Kerner, Engineer, Manager of the Austrian Federal Railways, and Mr. Auderieth, Headquarters Inspector, in 1924. In that year candidates for workshop posts were for the first time subjected to such tests; in 1928 similar examinations were applied to some other grades of employees, first of all as a trial, and as from 1932 these psychotechnical examinations were introduced much more extensively. At the present time the *Austrian Federal Rys.*' psychotechnical laboratory is under the management of Mr. Rudolf Auderieth, Engineer.

Since 1934 all new employees, before being engaged, are submitted without exception to psychotechnical examinations in order to ascertain their fitness for railway service.

As for employees already in the railway service, those who wish to become engine drivers, permanent way inspectors, track watchers, shop foremen, and assistant station-masters, have to pass a special psychotechnical examination before promotion.

In 1935, psychotechnical examinations were also made obligatory for shop foremen in the main workshops. The psy-

chotechnical examination staff of the Austrian Federal Railways obviously works in very close collaboration with the head of the staff offices in the different branches of the service.

*Present position of psychotechnical selection.*

On the Austrian Federal Railways psychotechnical examinations for the different branches of the service are carried out by means of five different series of tests, namely :

*Series I* : for locomotive drivers and rail-car drivers;

*Series II* : for firemen;

*Series III* : for station-masters, assistant station-masters, and train operating and commercial department staff;

*Series IV* : for the lower grades of operating staff, such as pointsmen, signalmen, shunters (foremen shunters), guards, etc.

*Series V* : for the shopmen.

These different series of tests are adapted to the respective branches of the service and are always divided into two groups : group examinations (9-10 different tests) and individual examinations (5-6 tests). (Specimens of series I and III tests are given in tables I and II.

TABLE I.

**Programme of tests, series III.**

| **Assistant stations masters** (*). (grammar school education). Series of tests : | **Fahrdienstleiter** (*). (Mittelschüler). Testreihe : |
|---|---|
| A) *Group examination :* | A) *Gruppenuntersuchung :* |
| (1) Test with missing words-6 (a railway accident). | (1) Lückentext 6 (Ein Eisenbahnunfall). |
| (2) Comparison of place names and numbers-1. | (2) Vergleichen von Ortsnamen und Zahlen I. |
| (3) Otis examination-2. | (3) Otisprobe 2. |
| (4) Calculation within a specified time (group 1). | (4) Rechnung unter Zeitzwang (Anordnung 1). |
| (5) Plurality of actions. | (5) Mehrfachhandlung. |
| (6) Examination of six words (group 4). | (6) Sechswortprobe (Anordnung 4). |
| (7) Carrying out orders given-1 (town plan). | (7) Besorgungsaufgabe 1 (Stadtplan). |
| (8) Noticing contradictions-II. | (8) Finden von Widersprüchen II. |
| (9) Examination of statement (country room) and report. | (9) Aussageversuch (Bauernstube) und Bericht. |
| (10) Ticket table-2. | (10) Fahrkartentafel 2. |
| B) *Individual examination :* | B) *Einzeluntersuchung :* |
| (11) Selection test. | (11) Reihungsprobe. |
| (12) Disc distributor. | (12) Scheibenausgeber. |
| (13) Ticket machine band. | (13) Fahrkartenlaufband. |
| (14) Speed of perception. | (14) Wahrnehmungsgeschwindigkeit. |
| (15) Movement of vehicles. | (15) Wagenablauf. |
| (16) Carrying out of important orders (sealed). | (16) Grosse Auftragserledigung (geschlossen). |

(*) Also for station-masters, acting station-masters and assistants, as well as for commercial department clerks.

TABLE II.

**Programme of tests, series I.**

**Locomotive drivers** (**).

A) *Group examination :*

(1) Ebbinghaus test.
(2) Making a report.
(3) Otis examination.
(4) Research examination.
(5) Order of words II.
(6) Examination of six words (group 3).
(7) Plurality of actions.
(8) Technical understanding.
(9) Direction of sounds.
(10) Examination of statement (country room) and report.

B) *Individual examination :*

(11) Speed of perception.
(12) Journey with use of brake.
(13) Closed apparatus.
(14) Shunting vehicles.
(15) Carrying out important orders (unsealed).
(16) Test driving cab for locomotive drivers.

**Lokomotivführer** (**).

A) *Gruppenuntersuchung :*

(1) Lückentext IV, V.
(2) Meldung erstatten.
(3) Otisprobe.
(4) Suchprobe.
(5) Wörterordnen II.
(6) Sechsworteprobe (Anordnung 3).
(7) Mehrfachhandlung.
(8) Technisches Verständnis.
(9) Schallrichtungsprobe.
(10) Aussageversuch (Bauernstube) mit Bericht.

B) *Einzeluntersuchung :*

(11) Wahrnehmungsgeschwindigkeit.
(12) Bremsfahrt.
(13) Schliesskasten.
(14) Wagenablauf.
(15) Grosse Auftragserledigung (offen).
(16) Lokomotivführerprüfstand.

In addition to the above grades, psychotechnical examinations are also obligatory in the case of permanent-way inspectors, permanent-way men (track watchers), signalmen, technical employees from secondary or higher schools, foremen, motor trolley and crane drivers, as well as shop apprentices.

At the present time, the Austrian Federal Railways have a laboratory with a manager and three permanent employees (two examiners and one assistant); if need be, former well experienced employees are taken on. There is no travelling laboratory.

Since 1928 (in the case of shop apprentices, since 1924) up to the end of 1935, the following men had undergone psychotechnical examinations :

116 permanent-way workmen;
310 permanent-way inspectors;
1 014 assistant station-masters (with grammer school education);
359 assistant station-masters (small stations);
242 drivers;
97 signalmen;
28 clerks in the accountant's department, with grammar school education;
292 employees with higher education, in the engineering, mechanical, or electrical departments;
44 shop foremen;
556 shopmen;
19 motor trolley drivers;
197 locomotive firemen;
2 792 shop apprentices;
——— making a total of
6 066 persons.

(**) Also for their assistants as well as for the drivers of rail motor vehicles, and electric motor coaches.

A maximum of 2 000 persons per annum can be examined in the psychotechnical laboratory.

As regards the scope of the examination, each new (first) test is recorded in the frequency statistics (Häufigkeitsstatistik) and its value is not determined until at least 100 persons have been subjected to it.

Candidates failing to pass the examination are not in principle accepted for railway service. The evaluation of the coefficient of agreement between the psychotechnical results and the opinion of the competent department is not yet generally made.

Should it happen — as it very rarely does — that there is a marked difference between the results of the examination and the practical classification of the employee, the two results are analysed and usually show that the practical results were in fact based on subjective and individual judgments which usually explains the pretended difference. Detailed verifications of the results have been made in the case of shop staff and the very interesting and instructive results shown by them have been published in the Psychotechnical Journal (see *Psychotechnische Zeitschrift*, Munich, 5th year, No. 2, pp. 29-42; No. 6, pp. 137-156 : article « Die Lehrlingsprüfung bei den Österr. Bundesbahnen », by Ing. R. AUDERIETH, Vienna, and Professor Dr. Hans RUPP, Berlin). Up to the present the Austrian Federal Railways have not published any statistics of the results of the psychotechnical examinations, as they have only been in extensive use since 1934.

Although before 1932 the representatives of the men's unions expressed some disapproval and were negative in their attitude as to the introduction of psychotechnical examinations to ascertain the suitability of employees for promotion, such examinations were not given up, and at the present time the men and their representatives no longer oppose them.

The Austrian Federal Railways therefore may be taken as considering psychotechnical examinations as useful.

The total expenditure on psychotechnical examinations reached 28 000 schillings in 1935; the average cost per candidate was about 13 schillings in 1935. Out of this sum, in round figures the cost for the staff was only 21 000 schillings in 1935, and the cost for equipment (maintenance of the apparatus and additions thereto) 1 300 schillings.

*Professional guidance.*

The Austrian Federal Railways have not introduced professional guidance, as up to the present the examinations to show suitability of candidates for railway service only apply to branches of the service fixed in advance.

*Instruction of railway staff.*

In the workshops, employees are always given three-year courses of instruction. During these courses all the manipulations and operations to be carried out by future mechanics are explained and taught theoretically and practically; the shopmen in addition are obliged to attend the improvement schools as laid down by law.

**BELGIUM. — Belgian National Railways Company.**

Length of lines in operation at the end of 1935 : 4 851 km. (3 014 miles).

Total strength of staff : 81 960 (December 1935).

The Belgian National Railways Company *does not resort to psychotechnical examinations* and only a medical examination is obligatory for all the staff. The Company has no organisation for the professional guidance of the staff.

*Instruction of the staff.*

There are no schools nor courses for

the children of the Belgian National Railway Company's staff. As regards instruction courses for specialist training, it may be stated that :

*Operating.*

A) Special courses were given to the assistant station-masters of the Brussels (Nord), Antwerp and Schaerbeek stations to train them in electric signalling, when this method of signalling was installed at these stations.

B) Operating and signalling courses have been organised for the 2nd and 3rd classes of station-masters, assistant station-masters, and station-masters of the lower grades seeking promotion.

C) Courses in commercial operating, including economic geography, rates, political economy, elements of civil law, transport law, and statistics, have been organised at headquarters for employees of the central offices and certain outdoor services.

*Locomotives and rolling stock.*

Courses are given :

(1) to locomotive staff;

(2) to candidates for the position of head foreman, in the repair shops.

*Permanent way.*

The permanent way department has organised :

1) courses for heads of permanent way sections, on signalling, interlockings, block and interlocked block apparatus, safety devices, electrical and mechanical equipment;

2) courses for electricians, on communication instruments, interlocking, block system, electrical instruments, and safety devices.

Improvement courses have also been organised for candidates for appointment as permanent-way inspectors and gang foremen when making provision for a competitive examination for a certain number of appointments in these grades.

*Staff.*

Shorthand and typing courses, both elementary and advanced, have been organised for the headquarters and outdoor staff.

* * *

*Methods applied for the instruction and improvement of young employees.*

Railway officials — except in the case of the shorthand and typing — which is taught by private teachers — give all the above mentioned courses.

*Operating.* — Young corresponding clerks and assistant clerks have always been placed as additional staff in the less important stations, where they learn all branches of the operating service. The probation period usually lasts twelve months. Young corresponding clerks recently recruited by the Company also undergo twelve months probation according to a definite programme of instruction.

They will remain nine months in a station of average importance, then one month in a large passenger station, and finally two months in a large marshalling yard.

Young engineers recruited by the operating department are sent in turn through headquarters offices and then different stations; in this way they are initiated into all branches of the operating service.

The train staff is recruited as temporary guards. They are not included in the permanent staff during the twelve months probation in the important depots. They are trained by means of weekly lectures and under the guidance of their seniors are initiated into all the details of the service.

*Locomotives and rolling stock.* — Young workmen during their apprenticeship work with their seniors, the ordinary workmen. As the shops are near the industrial schools, the appren-

tices are encouraged to attend these schools where they can acquire all the theoretical and practical knowledge they need.

*Permanent way.* — Immediately after being engaged, heads of permanent way sections and electricians have to follow improvement courses.

The instruction courses for the different specialist jobs last :

*Operating :*

Assistant station-masters : about three months;

The operating and signalling course : 10 two-hour lessons in each branch;

Commercial operating (traffic) : 15 one-hour lessons in each branch.

*Drivers and firemen :*

(*a*) obligatory theoretical and practical instruction for at least two hours a month for four years;

(*b*) voluntary courses : 50 lessons a year.

Courses for *supervisory staff, candidates shop head-foremen,* consist of 67 lessons.

The courses for *heads of sections* (permanent way) last two months, and courses for *permanent-way inspectors* and *gang foremen* are given in winter. The shorthand courses consist of 45 one-hour lessons, 15 of them being practice lessons.

All the courses are free.

There are also private professional schools in Belgium for the education of railway specialists, but these schools have not given any appreciable results for the railways.

**BULGARIA. — State Railways and Harbours.**

Length of lines operated at the end of the year 1935 : 2 795 km. (1 712 miles).

Total strength of staff : 16 688.

*Present position as regards psychotechnical selecting methods.*

Psychotechnical examinations for selecting and guiding railway staff have not been resorted to so far by the Bulgarian State Railways and Harbours. The question is still being investigated.

*Education of railway staff.*

Children of railwaymen attend the public schools. There are two boarding houses for boys and one for girls, supported by the Railways. The pupils live in them, but attend the public schools. Pupils are admitted after leaving the grammar school. Only special branches are taught at the professional training school.

The Bulgarian State Railways have no specialist training courses properly speaking; such teaching occurs at the professional school, where the courses are given by officials from the various railway departments and expert professors.

Young railwaymen are enabled to attend theoretical and practical educational and improvement classes.

There is no methodical organisation as regards the training of supervisory staff and a reserve of specialists.

Station employees attend special courses for three years, and men of the other services, for two years.

The results obtained from such training are considered satisfactory by the Railways.

**FRANCE. — Alsace-Lorraine Railways.**

Length of system in operation at the end of 1935 : 2 089 km. (1 298 miles).

Average strength of staff during 1935 : 29 912.

*Present position as regards psychotechnical selection.*

This Railway has no psychotechnical laboratory. The Alsace-Lorraine Railways do not examine their staff psychotechnically, and only medical examinations are obligatory.

*Instruction of railway staff.*

The Alsace-Lorraine Railways' professional schools for training apprentices as qualified workmen also give them a general education.

The Alsace-Lorraine Railways run specialist courses; they train apprentices for the following trades :

Fitter (accurate work) — metal turner — smith — boilermaker — electrician — joiner — painter and upholsterer.

The instruction given to the apprentices consists of manual professional training, completed by theoretical courses in the following subjects : native tongue, arithmetic, geometry, physics, technology, mechanics, electricity, drawing and sketching. The apprenticeship lasts three years. The apprentices do not have to pay any premium; on the contrary, during the whole of their apprenticeship, they receive a daily wage and half-yearly bonuses varying according to their time of apprenticeship and the progress they have made.

The theoretical courses are given by members of the private staff and railway officials, former pupils of higher schools.

The manual instruction is given, under the direction of the Head of the shop, by foremen or assistant foremen assisted by workmen of good moral and professional character.

*Methods used to train and improve the young employees.*

Employees taken on in the operating department receive a preliminary professional guidance by means of courses held by the most senior assistant station-masters, selected for their practical knowledge of the service.

These courses, which are given periodically, consist of twelve two-hour lessons at the most. The programme includes elementary notions of the organisation of the system in general, and the operating service in particular.

At the end of the course each beginner is classified according to the aptitude displayed in one of the three following classes :

1. operating or office work;

2. signalling, points operation, shunting or train working;

3. manual work in handling goods and in the lamp rooms.

In principle no employee on starting is put on shunting work until he has been at least one month in another branch of the service.

Employees responsible for the safety and running of the trains must pass the regulation aptitude tests before being assigned to it.

After following the first professional training course, the junior station employees with more than one year' service to their credit and having successfully passed a school examination, are admitted to a practical railway course.

This course is intended to give those attending it elementary instruction in all branches of the operating service. It is held once a year at each district headquarters, and lasts five weeks, with eight hours instruction a day.

The teachers are selected from the operating inspectors and controllers.

In addition to this course, lectures are organised for the benefit of junior members of the signal and train running service. Attendance at these classes is obligatory.

The station-masters and assistant station-masters giving these lectures explain to their pupils the rules they have to observe during their work.

These sittings are held in the stations so that members of the staff who have to attend them can do so at least once a month.

*Courses* are likewise organised in each of the permanent way divisions *for the signalmen and electricians (workmen, foremen)*. They consist of 18 or 24 lessons, according to the grades of

employee, one lesson being given every month.

The instruction is given partly indoors and partly outside, where apparatus dealt with in the course are located. Qualified inspectors are selected to give these courses.

*Periodical lectures* are given by the regional heads to the *maintenance men of the lower grades,* and by heads or assistant heads of sheds to the train staff, in order to instruct the men concerned in the carrying out of their duties.

*Training of specialist grades of railway employees.*

The Alsace-Lorraine Railways recruit every year for their specialist grades a certain number of candidates from the Higher Schools or possessing certain diplomas.

Before being admitted as officials, these candidates undergo a course of training, the length of which depends upon the general and professional knowledge of each individual. The average time is 18 to 24 months.

*A higher improvement course* has been introduced for men already employed in posts of some importance, who might be promoted to certain managerial posts in the larger stations or the Inspectorate service.

There are two series of such courses, one for the management of all the station services, the other for the management of the offices dealing with fast and slow traffic, and customs.

These courses are held once a year at the headquarters offices and last three months, at the rate of 8 hours a day. The course is given by inspectors and higher officials of the different services.

Other courses have been organised for training permanent-way inspectors, technical controllers (wood and iron) and controllers in the electrical and signal departments.

These courses are held at the headquarters before the examinations; they consist on the average of twelve lectures, each of two hours, given by qualified specialists.

Lectures on technical subjects are given monthly to drivers and electrical service supervisors, and quarterly to permanent-way section heads and assistants, in order to keep their professional knowledge constantly up to the mark. These lectures are given at headquarters.

Finally every year, the railway sends some 10 employees from different branches of the service to the Special Public Works School, Paris (Railway Section), to follow an improvement course for a year.

The chief object of these courses is to give gifted men a course of general instruction which will enable them to qualify for managerial posts for which such instruction is absolutely indispensable.

All these courses are free, and travelling expenses, in addition to their usual wages, are given to the men who have to travel to attend them.

There are private and official professional schools for training railway specialists :

*Private school* — recognised by the State — at the Special School of Public Works, Paris (Railway section);

*Official schools* instituted by the railway : these are schools for apprentices and the operating school.

The Alsace-Lorraine Railways consider these schools give commendable results.

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**LUXEMBURG. — Guillaume-Luxemburg Lines.**

Length of line in operation at the end of 1935 : 206 km. (128 miles).

Average total strength of staff : 3 667.

The information given about the Alsace-Lorraine Railways also applies to the Guillaume-Luxemburg Lines.

**FRANCE. — Est Railway.**

Total length of lines in operation at the end of 1935 : 5 132 km. (3 189 miles).
Total strength of staff : 58 826.

*Use of psychotechnical methods to select candidates.*

Up to the present psychotechnical methods have not been used on the Est to select candidates.

The Est has no psychotechnical laboratory; since the 1st February 1936, however, applicants for the posts of pointsmen and railcar drivers are examined in the French Nord Railway's laboratory.

No information can be given as yet on the results obtained.

*Instruction of railway staff.*

There are no special schools or after-school courses for railway employees.

In actual fact, the railway pays no subsidies to any school, but bursaries are granted to the children of employees attending some technical or professional schools.

On the Est there are no schools to train men for the railway service. The schools mentioned above give their pupils a general education at the same time as technical and professional instruction.

*Specialist training courses.*

The railway trains apprentices to make sure of sufficiently well trained technical staff. This apprenticeship is intended above all to supply the mechanical engineer's department with trained men and supervisory staff; it is also used, but on a smaller scale, to train electricians for the permanent-way department. The apprenticeship lasts three years. The training is theoretical and practical. The theoretical course is devoted chiefly to French, social legislation, hygiene, safety, algebra, arithmetic, physics, chemistry, technology, mechanics, and electricity.

The practical training depends on the trade the apprentice is specialising in (fitter, turner, smith, boilermaker, joiner, upholsterer, electrician, etc.).

In all cases the theoretical and practical instruction is given by railway employees, some of whom are employed solely to teach the apprentices, and others merely temporarily.

*Educational methods used.*

As a general rule the staff is instructed by foremen who give those under them the necessary instructions for carrying out the work then and there. In addition, the men are given regulations, service orders, handbooks, etc., about their duties, the equipment they have to use, etc.

In addition special steps are taken to train some categories of staff such as :

*Station staff.* — In the large stations, the yard foreman teaches the young shunters during the less busy periods about shunting operations and examining and repairing couplings.

Lectures are also given on signalling, small models of signals being available with which the lecturers can illustrate their meaning.

Other lectures, at which films are shown, are given on the following subjects :

Duties on fast goods trains (G. V.) and slow goods trains (P. V.); handling goods at stopping trains, using such implements as the lampman's pole, the shunter's pole, loading, securing, roping, weighing, and passing through the loading gauge; use of the rolling stock, allocation and control, loading grouped consignments and full loads, method of using loading appliances, shunting with engines, etc.

*Drivers and firemen. — Shed men.* — At every shed, five lectures lasting

one hour or if possible two hours, are given every month, one on the signalling regulations, one on the regulations applying to drivers and firemen, one on general instructions, one on engine details, and finally one about engine defects.

These lectures are given by the shed foremen or under-foremen, and are followed by questions to see if the lecture has been fully understood and to give additional explanations.

The attendance of each employee at the lectures is recorded.

*Examiners.* — Candidates for the post of examiner are recruited from the workmen and helpers, in the rolling stock department.

Candidates selected to follow the special courses remain three months in a training centre where special theoretical and practical instruction is given them.

The general programme is as follows :

1. *Work in the shop* (3 hours a day) : Running repairs, fitting bearings into the top of the boxes and on the journals, repairs to the Westinghouse brake, etc...

2. *Theoretical instruction* (3/4 of an hour daily) : General instruction on the duties of examiners, instructions about the steam heating of trains, the working and maintenance of the continuous brake, etc.

3. *Practical instruction* (4 hours a day) :

a) *In the shop* — examination of rolling stock coming in for repairs, and leaving the shops, in order to examine the different parts and find out the repairs required, special inspection of heating equipment, etc.

b) *In the marshalling yard :*

The instruction is given by a gang foreman under the supervision of a higher official.

Two months after the end of the course the candidates have to take the regulation examination for the position of examiner.

*Permanent-way men.* — For the permanent-way men there are sleeper adzing schools and so-called testing and training schools. The object of the adzing schools is to make the section foremen and under foremen and gangers proficient in re-adzing the sleepers as well as in remaking and adjusting the points and crossing timbers.

The training in the testing and training schools lasts two to three weeks, with the object of perfecting the theoretical and practical knowledge of the above mentioned grades and to teach them the first stages in managing a yard on methodical lines.

There is also an improvement school (at Pantin) for men in the electrical services, the courses consisting of general and technical instruction, lasting one month.

Finally, surveying courses are organised every year for such gang foremen and permanent way inspectors as are likely to profit from them; these courses are obligatory for candidates for appointment as gang foremen, and consist of four to six four-hour lessons.

In addition to these surveying courses, candidates for the post of gang foreman receive instruction in all the subjects on the examination programme for this post. This training consists of 18 to 34 lectures, each of 2 to 3 hours.

*Office staff.* — Courses by mail on general and practical matters are given to copying clerks in the permanent-way and rolling stock departments, preparing for examination for the post of corresponding clerk.

Drawing classes are held in the divisional areas to enable draughtsmen to improve themselves and make it easier for the junior draughtsmen to qualify for these posts. Draughtsmen also follow surveying courses.

* * *

Apart from the above measures intended to give the staff the necessary knowledge for the post they hold, the railway has taken various steps to make it easy for the staff to rise to the higher grades.

*Higher professional courses* have been organised in the locomotives and rolling stock departments to train shop managers. Such courses are divided into two parts, one for the locomotive shops and the other the carriage and wagon shops. These courses are taken every year by fifteen higher-grade employees.

The pupils are selected competitively from among the former apprentices and former pupils of practical or professional schools.

The higher professional courses for rolling stock men last 15 months; in the case of men for the locomotive shops, eleven months in the Epernay shops and four months in a locomotive depot.

Those who have given satisfaction at the end of these courses are promoted to posts for which their general knowledge will enable them to make the most of themselves and those with good results can expect to be promoted to managerial posts.

There are also courses for locomotives and rolling stock department employees wishing to qualify for promotion as locomotive inspector and assistant shed foreman.

These courses consist of two years' study, each lasting nine months. The first year is devoted to theoretical instruction, the second to technical training.

Finally, in 1935 six men were sent to the Special Public Works School. The men in question do not work on the railway at all during the school year (9 months), but follow a course in the Railway Section, which was introduced in this school with the collaboration of the French main-line Railways and is intended to perfect the general training of candidates and improve their technical knowledge.

The instruction given in the Railway Section during the first term of the school year deals with matters common to all the departments while during the two other terms the courses are subdivided according to the branch of service — operating — permanent way and works — locomotives, rolling stock.

The general educational courses are given by the staff of the Public Works School; the professional courses are given by higher railway officials.

All the different courses and lectures for the staff are free; they take place — with the exception of the course by mail — during working hours of the men who receive the same wage while attending them as when carrying out their usual duties.

As the first men were only sent to this School in 1935 it is not yet possible to estimate the benefit they have obtained from the instruction given.

**FRANCE. — French State Railways.**

Length of lines in operation at the end of 1935 : 9 594 km. (5 962 miles).

Total strength of staff : 71 998 permanent, 3 734 temporary.

*Psychotechnical selection.*

The General Manager of this Railway, Mr. N. Dautry was the initiator of the psychotechnical tests, which were started in 1935.

At the present time the Company's psychotechnical laboratory is run by Dr. Laugier, Professor of physiology of work at the Sorbonne Institute, and his assistant Miss Weinberg, Director of Work at the School of Higher Studies, Lecturer at the National Institute of Professional Orientation.

At the present time youths applying for an apprenticeship in the locomotives and rolling stock department, employees who have to drive railcars or electric

locomotives, or become signalmen, and young men to be used in the operating department are all required to pass a psychotechnical examination. In addition, employees are examined individually for various reasons (for example mistakes, working accidents, etc.).

*Professional training and improvement.*

The men recruited for the various branches of the service, before being permanently taken on, have to undergo a trial period during which they learn the practical side of their trade; afterwards the pick of them follow the courses at the Rouen school.

There is at Rouen a school for each branch of the service, where all the subjets connected therewith are taught, and general instruction given in other branches of the service.

There are also special courses for the training of specialist grades :

(*a*) Electrical service school — Signalling (Bécon).

(*b*) Examiners' school (Le Mans).

(*c*) School for locomotive running men (Batignolles).

(*d*) Improvement school for under-gangers (Montrouge).

(*e*) School for railcar drivers (Auteuil).

(*f*) Improvement school for locomotive inspectors (Le Mans).

(*g*) Training school for permanent way gang foremen (Nanterre — Le Mans — Bécon and Nantes).

Finally a certain number of men every year attend the courses at the special School of Public Works (a private school in Paris).

Psychotechnics have been applied since 1935 in the instruction and training of apprentices (investigated in 1932), and since 1934 of railcar drivers and pointsmen. The examination of future operating department employees will be introduced later on.

The official ordinances had not been put into force.

*Present position as regards psychotechnical selection.*

The programme of psychotechnical tests is as follows :

The examination includes anthropological measurements, physiological tests (breathing and circulation), psychomotory and sensorial tests, reaction tests (selection and emotivity), vigilance, memory and intelligence, and in particular technical intelligence.

The tests used for the different classes of men are often very similar, sometimes identical; but the practical importance attributed to one or other of the tests varies according to the professional specialisation of the subject.

The State Railways have a permanent psychotechnical laboratory but no travelling laboratories.

In 1935 examinations were made of :

| | |
|---|---|
| 1. Pointsmen (signalmen) . . . . | 225 |
| 2. Railcar drivers . . . . . | 431 |
| 3. Drivers of electric vehicles . . . | 39 |
| 4. Apprentices . . . . . | 613 |
| 5. Special cases (men of various categories) . . . . . | 19 |
| Total . . . | 1 327 |
| Office clerks (group examination only) . . . . . | 550 |

These figures are the maximum possible with the present equipment. In the future they will be increased.

Two methods are employed at the present time for appraising the results of tests : on the one hand the method of deciles (tenths), on the other tables of values. A value

$$\tau = \frac{x - \tau\, x}{1/4\ \sigma\ x}$$

($x$ being the value for a subject, $\tau\ x$ the average, $\sigma$ the average quadratic difference).

As regards the value to be taken as the lowest allowable limit of professional

ability for passing the examination, this depends on the tests and the trade, the 10th decile $\tau < -5$, etc.

The young men are guided in their choice of a career; candidates in the railway's apprenticeship schools who have failed in the entry examination are advised in their choice of a career according to the results of the medical and psychophysiological tests they have already undergone.

The State Railways Administration has no statistics to show if accidents and sickness have decreased, thanks to the application of psychotechnics.

Up to the present time the men have not protested at having to pass psychotechnical examinations. The management of the railway favours the use of these examinations.

The total expenditure on the psychotechnical examination of the staff was about 240 000 francs in 1935; the average cost per man was 100 to 150 francs according to his trade.

The actual cost of equipping the psychotechnical laboratory is :

| | |
|---|---|
| Buildings . . . . . | 80 000 francs. |
| Equipment . . . . . | 225 000 francs. |

The Administration intends to increase the scope of its psychotechnical laboratory during 1936.

*Instruction of railway staff.*

Schools for the children of employees and Sunday and night schools are not in principle subsidised by the Administration.

Apprentices follow courses of general education which in fact continue the elementary schools in the form of continuation classes.

The State Railways run training courses for certain specialist grades as already mentioned above.

**FRANCE. — Nord Railway Company.**

Length of lines in operation at the end of 1935 (including the *Nord-Belge*) : 4 092 km. (2 543 miles).

Average strength of staff : 67 255 employees.

*The application of psychotechnical tests.*

In 1927 the Nord instituted an Organisation Committee to study the application of the principles of the organisation of labour in the different branches of the service. This Organisation Committee initiated the use of psychotechnical methods on the Nord.

Psychotechnical investigations began in 1930 and continued during 1931, in connection with the mechanisation of accountancy work.

The Nord Railway's psychotechnical laboratory was put into service in 1932 and from that year pointsmen (signalmen) have been selected by this means.

The psychotechnical service is controlled by the Assistant Manager of the Operating Department, and the scientific management of the laboratory is in the hands of Mr. J. M. Lahy, Research Director of the Practical School of Higher Studies, and Professor at the Psychological Institute of the Paris University.

At the present time the following classes of men are examined psychotechnically : pointsmen (signalmen), and railcar and road vehicle drivers, clerks on calculating and statistical machines. The psychotechnical tests will be applied later on to drivers, porters, guards, shunters and timekeepers.

*Professional training and improvement of new recruits in the different departments.*

According to the regulations in the Statute common to all the French mainline Railways, men taken on the permanent staff have to undergo a preliminary probation period of one year during which their physical, intellectual and professional aptitude is checked.

The training and improvement of new

employees, usually takes place while they are at work, thanks to the advice given by the supervisory staff who provide them with orders or regulations applying to the whole service or work.

Periodical lectures are given by the supervisory, managing or inspection staff during working hours (obligatory lectures) or outside working hours.

New employees are closely watched and the results entered into special reports.

Unsatisfactory employees are dismissed on the decision of the Head of the Department, while those who have given satisfaction are taken on as junior or senior members of the staff.

As regards the training of young engineers admitted on leaving the Higher State Schools (Polytechnical, National School of Bridges and Roads, etc...), this is done at a special professional training centre.

A committee has been set up by the Nord Railway to get close collaboration between the different departments and the psychotechnical service and determine the order in which the researches are to be carried out and the results obtained, applied.

*Present position as regards psychotechnical selection.*

A certain number of general tests (intelligence, memory, attention under their various forms, etc.) and particular tests in connection with professional specialities have been perfected.

Particular tests are being worked out for drivers and learner drivers, stationmasters, their assistants, head shunters, and men in the marshalling yards.

Different tests are used for the railcar drivers, i.e. tests as to intelligence, various forms of memory tests, concentrated attention, or lack of vigilance, understanding and carrying out simple orders given in rapid succession, speed and regularity of reaction time, liability to nervous and muscular fatigue, rapiditiy of adjustment to simple motions, dissociation of movements with the hands, muscular strength and stability, etc...

The tests for pointsmen and signalmen are practically the same. In addition employees on calculating and statistical machines, both male and female, are examined psychotechnically by means of special tests.

The Nord Railway has a psychotechnical laboratory in Paris; since 1932 to date about 4 600 examinations have taken place in it. About 2 500 men can be dealt with during the year.

*Statistical methods used to estimate the results of the tests and the qualifications of the men examined.*

A. *Examination of curves.*

1. Individual curve known as the Galton ogive.

2. Frequency curve, known as the Gauss curve.

B. *Calculation of the numerical factors of a distribution :*

1. Representative values of the series : arithmetical mean (sometimes geometrical or logarithmical mean), median, mode.

2. Precision coefficients on the representative values : probable error on the average or median.

3. Dispersion indices : average variation, difference, standard.

C. *Drawing up the tables.*

1. Calculating the centiles (hundreth parts) of a distribution.

Usually the limiting values are calculated by 10, 20, 30 ..... 90th centiles (hundreths), i.e. by deciles (tenths).

2. Calculating tables by means of the differences from the average. The standard difference and its fractions are generally used.

3. Tests showing more or less importance in the range of tests are given attenuating coefficients fixed after investigation.

D. *Expression of the total value of an employee :*

1. Graph in the form of a psychological or psycho-physiological « profile ».

2. Sum total of the whole of the marks fixed according to certain constants.

The employees examined are graded under the headings : very good, good, medium class one, medium class two, and eliminable. At the present time, medium class one is the lowest limit. Candidates found to be totally unfit after various examinations (examination in general knowledge, medical, psychotechnical) are not engaged.

The coefficient of correlation between the psychotechnical results and the opinion of the competent department, i.e. the agreement between the psychotechnical and professional results varies between 70 and 90 %. The Yule, Spearman, or Pearson formulæ are used.

As the Nord Railway's laboratory was only put into service in 1932 and psychotechnical examination of men already in service could only be made under exceptional circumstances, definitive conclusions cannot yet be drawn from the figures obtained from the available statistics.

When it was decided originally that only men who had passed psychotechnical examinations would be employed as pointsmen (signalmen), the men's delegates were enabled to visit the laboratory and inspect the methods used. Since then no objections have been raised against them.

The railway authorities are in favour of the psychotechnical examinations. There is no objection to them so long as a purely experimental method is not used until its value has been fully demonstrated.

The cost of running the laboratory has been 250 000 francs in 1935, of which approximately 230 000 francs were spent on the administrative and scientific staff.

The average cost per employee examined in 1935 was 200 francs, but it must be noted that during 1935 only 1 200 persons were examined, as certain investigations, in particular those relating to accidents at work, slowed down the work of the laboratory. Under normal conditions the cost should be about 100 francs.

Up to the present the cost of equipping the laboratory has been about 400 000 francs for buildings, apparatus, etc. The average annual expenditure for maintenance and upkeep, and to complete the equipment is about 20 000 fr.

* * *

The Nord Railway has not set up any organisation for the professional guidance of learners.

* * *

*Organisation of apprenticeship and technical education on the Nord Railway.*

I. — **Organisation set up by the railway at its sole charge.**

A. *Locomotive and rolling stock department.*

The general programme is as follows :

First of all training in 5 special apprenticeship and technical centres, for the young men who are to become skilled workmen, some of whom are trained for special duties by following such courses as those for examiners.

Men specially suitable for locomotive driving are selected from the shop staff and attend local technical improvement classes.

Finally, and most important of all, the methodical training of supervisory men from the shops and the locomotive department in various schools.

This programme makes it possible for the pick of the men to get, at the expense of the railway, the necessary ge-

neral and professional training to become foremen and have access to the various grades.

*Organisation of apprenticeship.*

The locomotives and rolling stock department has instituted four schools for apprentices, to train its workmen.

Boys of 13 to 17 years of age are admitted to these schools after examination; they are generally the children of employees or orphans looked after by the Nation, who bind themselves by deed of apprenticeship to join the permanent staff of the Nord when their training is completed. These schools train workmen for the different trades required in the locomotive and wagon shops. Apprentices are trained as fitters, turners, pattern makers, joiners, smiths, boilermakers, saddlers, upholsterers, and electricians.

Three years are spent in these schools during which the apprentices are given theoretical and professional instruction including practical instruction and the actual participation of second and third-year students in the work of the shops (locomotive, carriage and wagon shops).

At the end of the course the apprentices who have obtained their apprenticeship certificate can be employed as workmen or helpers and distributed through the shops in the different trades, according to their qualifications and the requirements of the service.

These apprentices are the pick of the shopmen from which the junior grades of the staff will be recruited in the future.

In 1935 the average number of apprentices was 350.

As a subsidiary organisation for technical training, the Nord Railway also has a school for rolling stock examiners, and one for locomotive examiners, and finally a brake school, besides certain study centres for head drivers and assistant shed foremen, and courses for railcar drivers and maintainers.

B. *Permanent-way department.*

As in the case of the rolling stock and traction departments, there are apprenticeship courses and improvement classes for qualified men, in addition to a series of lectures, either on the railway itself or outside, for the professional training of the intermediate grades, which have become of particular importance in recent years.

*Apprenticeship course organised in the permanent-way shops at Moulin-Neuf (Oise).*

The apprenticeship lasts three years. Candidates must be between 13 and 17 at the most. They are chosen in the first place among the sons of railway employees, and their acceptance depends on medical inspection and psychotechnical examination. They are trained as fitters and joiners in the permanent-way shops.

The method followed during the apprenticeship is a rational succession of duties during which the young men master their special trade. Practical work is thus carried out according to the canons of modern industrial discipline and completed by theoretical courses given by a professor, which include elementary arithmetic, geometry and industrial drawing.

At the end of the third year the apprentices who got satisfactory marks in the last half-yearly examination receive a diploma and, according to their qualifications and service requirements, are incorporated into the permanent staff of the railway.

In addition, training courses have been instituted for the signalling staff and electrical services, as well as to train the intermediate and higher supervisory grades.

C. *Operating.*

In the operating department the professional training of the men takes place

mainly during work, and particular care has been taken to train the supervisory staff.

A training course for assistant station-masters, introduced in 1932, enables them to complete their professional training and get practical advice about their duties and the responsibilities of the station master. They attend some forty lectures about all branches of the operating service, given by headquarters officials.

In 1933 courses to complete the professional training of express and slow-goods agents were also started.

## II. — Courses followed by men outside the railway.

### School of Public Works at Paris. (Special Railway Section.)

Some fifteen specially selected men of particular aptitude and merit are sent for the whole school year to these courses, organised in collaboration with the French main-line Railways by the School of Public Works, Paris.

The object of these courses is to enable the men to improve their general knowledge and professional training and thus qualify better for the intermediate or higher supervisory posts.

*School of Higher Commercial Studies.*

Some men attend evening classes at this school to learn the special subjects needed for improving their work on the railway. The fees are paid by the railway.

Other men follow courses in industrial electricity at the « Conservatoire des Arts et Métiers », practical courses in autogenous welding, heating, etc., at the expense of the railway.

* * *

The same regulations as on the French Nord Railway are applied on the « Nord-Belge ».

### FRANCE. — Paris-Lyon-Mediterranee Railways (P.L.M.)

Length of lines in operation at the end of 1935 : 9 948 km. (6 182 miles).

Total strength of staff : 107 445 men.

*Application of psychotechnical tests.*

As soon as the Paris-Lyon-Méditerranée extended railcar services on its system, it saw the necessity for a very strict selection from the psycho-physiological point of view of the men who were to drive these vehicles as their reactions have to be very quick during their work.

Up to date the P. L. M. has no organised means of selecting its staff by psychotechnical methods; to do so it has to make use of the French State Railways' laboratory.

The first psychotechnical investigations were begun in October 1935 and covered railcar drivers as well as candidates for this post.

The P. L. M. proposes to extend psychotechnical selection to signalmen and candidates wishing to become signalmen.

The programme of psychotechnical examinations for selecting railcar drivers and signalmen is the same as that in force on the State Railways.

Up to March 1936, about 150 men had been examined.

As the psychotechnical tests are only in their initial stages, the P. L. M. cannot yet express an opinion on their usefulness; up to the present it has only been possible to draw certain indications from the tests which will be a guidance for the future.

The P. L. M. does not as yet require men wishing to be employed on the railway, to undergo psychotechnical examinations, nor is this method applied to professional training. The professional guidance of the staff according to psychotechnical methods is not practised on the Paris-Lyon-Mediterranée Railways.

The average cost per person examined psychotechnically is about 170 francs.

*The instruction of railway staff.*

Two elementary schools and one kindergarten have been started by the P. L. M. for the children of employees. The Railway itself carries on these three schools.

In addition, the Company has a system of education allowances for the children of employees attending certain carefully selected training schools, or secondary or higher schools.

Finally the Company helps in certain professional training courses at places where its employees are particularly numerous.

In principle, schools or courses instituted by the P. L. M. for the training of staff are purely professional, but the pupils are chosen from amongst those of sufficient general education to profit by the training.

In order to increase the general education of its staff, the P. L. M. has organised adult classes for men with only a very elementary education.

Certain men with sufficient professional knowledge to make good foremen are sent every year to the School of Public Works, to perfect their general education and bring it in line with their technical knowledge.

*Training of specialists.*

*In the Operating Department* there are :

— *train operating schools* to train and perfect employees for this work;

— *traffic schools,* in which the necessary information about rates, railway accounts, and claims is taught;

— courses to train the train staff;

— shunting and goods handling schools;

— *courses* to train men in the enquiry offices, signalmen for signal and points staff, men driving tractors and locotractors, and also courses to train men dealing with goods rates.

In the *locomotive and rolling stock department,* lectures are given to drivers.

The instruction given in all these courses and schools is given by higher-grade employees specialists in the subjects concerned.

In the operating department, men who have shown particular aptitude for managerial posts are sent according to their special job to the *Higher Train Movement School* or the *Higher Traffic School.*

Here they are thoroughly grounded in railway matters and trained to enable them to be promoted to important stations or offices.

In the rolling stock and locomotive department, there is a « School of Applied Traction Work » intended to train technically and professionally assistant shed foremen, running inspectors, and head drivers.

A « Railcar School » is intended to train the men driving and maintaining railcars, and the supervisory grades for this branch.

The length of these courses varies, according to their importance, from 2 weeks to 10 weeks, and about three months in the case of the higher train operating and traffic schools.

The courses and schools are absolutely free.

**FRANCE. — Paris-Orleans and Midi Joint Railways.**

*Paris-Orléans Railway (P. O.).*

Length of lines in operation at the end of 1935 : 7 070 km. (4 393 miles).

Total strength of staff : 52 314.

*Midi Railway.*

Length of lines in operation at the end of 1935 : 4 227 km. (2 627 miles).

Average total strength of staff : 31 831.

*Application of psychotechnical tests.*

The Paris Orléans-Midi Railways do

not apply psychotechnical tests to their staff in any way.

*Instruction of railway staff.*

As regards schools for the children of employees and night-school courses, the P. O. Railway only have an elementary school at Paris for the daughters of its employees. Commercial, typewriting and shorthand courses are also given at this school which is attended by about 450 pupils.

In addition the P. O.-Midi subsidise a certain number of private schools, particularly in Paris, Bordeaux, and Périgeux, and has bursaries in certain technical, industrial and commercial institutes. Two Sunday and night-school training courses at Bordeaux are also subsidised.

The P. O.-Midi's professional schools also give the pupils a general education, i.e. in the form of theoretical courses during the first two years' apprenticeship (French, arithmetic, hygiene, civics, geography, etc.).

The P. O.-Midi train the following specialists :

Fitters (erectors);
Wagon fitters;
Electrical fitters (mechanical department);
Electrical fitters (permanent-way);
Boilermakers;
Smiths;
Turners;

and in addition on the P. O. :

Painters, saddlers, joiners, moulders, pattern makers.

The general education is given by men with good general knowledge, who have given satisfaction during a trial period.

The professional courses are given by technicians, usually foremen or underforemen, whose competence is beyond doubt.

*Methods used on the P. O.-Midi to instruct and train young men.*

During their three years apprenticeship, the young men are trained progressively by means of :

1. theoretical courses with demonstrations (first year);

2. practical work, from progressive exercises to working and repairing the stock (second and third years);

3. (only on the Paris-Orléans) — evening classes or optional training classes for adults after working hours.

(*a*) There is also methodical training for specialists in the higher apprenticeship courses. These courses last 3 years and only the pick of each year's apprentices are admitted to them (1/10 of the apprentices).

(*b*) In addition there is a supplementary year of apprenticeship, technical training before the period of military service, under the same conditions as for the best 1/10th of the apprentices of each year.

(*c*) In addition there are improver courses for the working services (to educate foremen, head drivers, head electric drivers, and assistant shed foremen). These courses last 30 months; there are no such courses on the Midi Railway.

(*d*) There are improver courses for the train examiners. Such specialists are also trained on the Midi.

All the above-mentioned courses last three years and are free.

A small number of employees (P. O. and Midi) are sent every year to follow a course at the Public Works School and a very small number are likewise sent to the Autogenous Welding Institute and the School for the Scientific Organisation of Work (private).

Finally a few employees attend electric traction courses at the « Conservatoire des Arts et Métiers ».

The results of the training given by these schools and courses has satisfied the Paris Orléans-Midi Railways.

**FRANCE. — Ain Tramways.**

Length of line in operation at the end of 1935 : 450 km. (279.6 miles).

Total strength of staff : 400.

The Ain Tramways Company makes use of psychotechnical methods in selecting candidates for the job of conductor. In addition to diminishing the number of accidents, this selection considerably facilitates the apprenticeship as only well endowed persons are trained by the Company.

The Manager of the Company took the initiative in introducing psychotechnical tests. Psychotechnical investigations were begun in 1933, and at the present time the psychotechnical laboratory is run with technical help from Mr. Lahy, Professor at the Institute of Psychology of the University of Paris. 190 employees had been examined up to the end of 1935; 600 persons can be examined in the course of a year. The correlation between the psychotechnical tests and service results has been found satisfactory. The total expenditure on psychotechnical examination of the staff in 1935 was 5 000 francs; the average cost per employee was 50 francs. The present cost of the equipment of the psychotechnical laboratory is 40 000 francs; the average annual expenditure on it being 1 000 francs.

**GREECE. — Hellenic State Railways.**

Length of lines in operation at the end of 1935 : 1 320 km. (820 miles).

Total strength of staff : 5 472.

The Hellenic State Railways have not yet applied psychotechnical investigations.

As regards the professional training of the staff, these Railways' present regulations require newly recruited employees to work during their apprenticeship in the departments to which they belong, and since 1928 a supplementary training school has also been organised.

In addition two private schools at The Piræus train drivers.

The results are fairly satisfactory.

**HUNGARY. — Royal Hungarian State Railways.**

Total length of lines in operation at the end of 1935 : 7 814 km. (4 855 miles).

Total strength of staff : 52 521.

*Present position as regards psychotechnical selection.*

Certain psychotechnical methods have been used experimentally by the Royal Hungarian State Railways during recent years, to select the staff.

Up to the present, psychotechnical examination has only been used to select certain grades of the outdoors staff. Its more extensive application is under consideration.

In view of the fact that the matter is only now being organised, the Royal Hungarian State Railways cannot give more detailed information until more experience has been obtained in the future.

**RUMANIA. — State Railways.**

Length of lines in operation at the end of 1935 : 11 129 km. (6 905 miles).

Total strength of staff : 82 883.

*Present situation as regards psychotechnical selection.*

The selection and orientation of the Rumanian State Railways' staff by means of psychotechnical examinations has *recently been introduced,* so that it is not yet possible to give any useful information on this matter, as precise results are not yet available.

*The training of the railway staff.*

Children of employees can attend the elementary railway technical schools, at which only children who have only passed through the elementary schools are accepted as a general rule.

The Rumanian State Railways have

traction, shops, train operation, stores, maintenance, etc., schools, at which courses are held to train specialists in all trades. Usually such courses are given by railway employees with special educational qualifications — engineers, holders of diplomas — or specialist professors.

Young employees are trained and improved by theoretical and practical lessons, according to the special analytical programmes of each school.

At the elementary technical schools, the courses last four years. At the same time, theoretical and practical instruction is given.

school lasts 9 months, and the practical training 2 months.

The traction school lasts 19 months, the training, both theoretical and practical, being given during two consecutive years. At the intermediate stores school, the theoretical and practical courses last 9 months. At the intermediate maintenance school the theoretical and practical training lasts 18 months, so that it is given in the three terms of two consecutive years.

The intermediate shop school lasts two years after the preparatory year. The higher operating school lasts 9 months. The elementary maintenance school (for the heads of gangs) lasts 9 months, the instruction being both theoretical and practical. The elementary train operating school lasts 6 months.

All the courses are free, and in addition the pupils are lodged and fed free of charge.

In Rumania, there are also private and official training schools for railway specialists, which give satisfactory results from the railway's point of view, so that the Management is continuing to support the existing schools and even going to start new schools.

**SWITZERLAND. — Swiss Federal Railways.**

Length of lines in operation towards the end of 1935 : 2 940 km. (1 827 miles).

Total strength of staff : 29 500.

*General and historical information.*

The initiative in *introducing psychotechnical tests* was taken in 1923 by Mr. J. Schnurrenberger, Engineer, Head of the Shops Department at Berne Headquarters, and Mr. R. Leupold, Managing Secretary, at Basle. Psychotechnical examinations have been used since 1923 in selecting trade apprentices for the Olten shops, and since 1928 for station apprentices (station-master, operating, and administrative staff). At the present time the psychotechnical laboratories are run by Mr. P. Knoblauch, Operating Inspector and Head of the Psychotechnical Service of the Staff Department at Berne Headquarters.

Candidates for apprenticeship in the five main shops, and candidates for employment on the station and train staffs have to pass psychotechnical examinations.

A programme for the examination of assistant drivers is ready for use, but for the moment no locomotive staff is being recruited.

The professional training and improvement of newly recruited employees is by practical apprenticeship in the respective departments, together with more theoretical instruction courses.

Before being employed in their various duties, candidates must pass an examination.

Up to the present psychotechnics have not had any direct influence on the training of the staff.

No *official* order has been passed on the obligatory application of psychotechnics to the training of the staff.

*Present position as regards psychotechnical selection.*

The programme of obligatory psycho-

technical tests for the various branches of the service is as follows :

(1) *Candidates for the locomotive department* (drivers, assistant drivers, firemen, drivers of railcars and electric locomotives and vehicles) are examined in their native tongue, mathematics, practical intelligence, memory, attention, reaction, sense of smell, taste for the work, and character.

(2) *Station and administrative staff* (station-masters, their assistants, clerks) are examined on the following points : native tongue, second national language, and if need be other foreign languages, mathematics, geography, civics, intelligence, memory, attention, reactions, taste for the work and other characteristics. The candidates for the train service are examined like the candidates for the station services, but more simply.

(3) Signalmen, dispatchers, foremen shunters and men employed in shunting yards : no examination.

(4) Workmen are not examined psychotechnically, and only trade apprentices have to pass an examination before they are accepted. This examination covers the following subjects : native tongue, mathematics, practical and technical intelligence, memory, sensitiveness of touch, sensitiveness to pressure and movement, manual dexterity and taste for the work.

The Swiss Federal Railways have a laboratory at Lucerne for the locomotive service, and also two travelling laboratories, one at Berne for the station and train staff, and one at the Olten shops for trade apprentices.

3 300 persons had been examined up to the end of 1935, viz : 1 900 shop apprentices, 1 150 station apprentices, and 250 train staff apprentices.

With the present staff of two examiners and two or three assistant examiners about 700 persons can be examined yearly.

The results of the different tests of the aptitude examination properly speaking are given as percentages based on the results of a large number of examinations. The remarks on the aptitude and character of the examinee are given in writing.

For the qualification of trade apprentices, the following headings are employed : sufficient, insufficient, in addition to a classification according to the total results; for the station and train staff services a general report on the aptitude of the candidate with the concluding remark :

(*a*) Very good aptitude.

(*b*) Good aptitude.

(*c*) Sufficient aptitude.

(*d*) Insufficient aptitude.

The lowest permissible limit for professional candidates is general satisfactory results, and at least 600 marks out of 1 000; for the station and train staff in general at least sufficient aptitude.

Candidates in excess of requirements who have passed the examination receive a notice to this effect, but no other attention is given them.

The agreement (coefficient of correlation) between the psychotechnical and service results in *absolutely satisfactory.*

In the rare cases in which candidates have not been examined, this was not on account of lack of capacity but owing to unfavourable circumstances or as a result of their character.

In the shops, a practical check has shown that 64 % of the apprentices were classified above the average by the examiners, 30 % given a good average and only 6 % found not good enough.

In the case of the station apprentices, the practical check together with the psychotechnical appreciations may be considered excellent.

As regards the attitude of the men towards compulsory psychotechnical examinations, the staff do not object, are

more or less in favour of the idea, and have given proof of their interest in the tests.

In general the railway authorities consider the psychotechnical examinations are useful, but there are also some high officials who do not attach much importance to the aptitude examinations. Up to the present no definite objection has been put forward, nor direct criticism.

As regards the total expenditure and the average cost per employee for psychotechnical examinations, the Swiss Federal Railways state that the present period is quite exceptional. Recruiting of new staff has been reduced to the strict needs. It is much lower than the average service requirements, so that naturally the cost of the examination is much greater owing to the fixed charges. In 1931, for example, 700 men were examined, and only 250 in 1935. The salaries of the examiners is the chief item of the fixed charges. The total cost per candidate was about 20 to 25 Swiss francs in 1931, and about 60 francs in 1935.

Up to 1935, about 15 000 Swiss francs had been spent on equipping and building the psychotechnical laboratories. The maintenance and completion cost was about 500 Swiss francs in 1935.

*Professional guidance.*

The psychotechnical service is not concerned with professional orientation. Aptitude examinations are only made of applicants for given railway posts.

*Instruction of railway staff.*

The Swiss Federal Railways have no schools for the children of employees; neither have they any professional schools.

They have two sorts of training courses for the staff of the various departments :

(a) *Obligatory courses* for apprentices, intended to complete the practical apprenticeship; for example, in the station service a four-week course at the end of the two years' apprenticeship. In addition the apprentices are gathered in groups of 5 to 30 at a convenient centre.

(b) *So-called instruction courses* which the staff attend periodically for about 1 to 2 days every 2 to 4 years. These courses are intended in particular to complete their professional knowledge, to discuss service matters, etc.

The masters and lecturers at these courses are generally high-grade railway officials. The administration subsidises optional instruction courses, particularly language courses. Leave with half pay is also granted qualified officials wishing to learn another language abroad.

The instruction and training of young employees is chiefly practical.

Beginners are sent separately to various stations or allotted to given officials : instructor, station-masters instructor, drivers instructor, etc.

The courses are intended above all to extend, complete and revise the employee's knowledge.

There are regulations and general rules on the training of men for the various supervisory grades and the professional instruction to be given. The plan of the actual education, and the method followed are left to the discretion of the master.

In the main shops, the professional apprentices pass the first year in the apprentices shop, where they work according to a definite programme.

The courses last, for example :

2 years in the station services;
9 months at least for drivers;
4 years for the trade apprentices;
1 year at least for apprentice drivers in addition to the period of apprenticeship as fitter or mechanic;

1 to 14 days at the most for ordinary workmen, and about 14 days for shunting staff.

The educational courses and the training periods are considered as part of the service. Those taking part in them and the apprentices are paid according to the special regulations.

There are some national and local schools as well as private institutions where men can be trained for station and office work. But at these schools the main object is to give a good general education and teach languages. These schools are not subsidised by the railway. Their pupils have to meet the same conditions for admission to railway employment as other candidates, and it does not matter very much if they have some technical knowledge of railway matters.

The results of the training given in these schools are on the whole satisfactory.

**Bernese Alps Railways (Berne-Loetschberg-Simplon).**

Length of lines in operation towards the end of 1935 : 251 km. (156 miles).

Total strength of staff : 1 027.

The information given by the Swiss Federal Railways on the recruiting and training of the staff also applies to the Bernese Alps Railways.

**CZECHOSLOVAKIA. — Czechoslovak State Railways.**

Length of lines in operation at the end of 1935 : 13 509 km. (8 395 miles).

Total strength of staff : 138 123.

*Psychotechnical tests of Czechoslovak State Railway staff.*

The Ministry of Railways of the Czechoslovak State was the first State Department to introduce obligatory psychotechnical examination of the staff under its control, i.e. for the Czechoslovak State Railway staff, in 1923. These examinations are intended to facilitate better and more certain selection of young employees for railway service; in the first place they were only introduced for drivers. They were then extended in turn to the drivers of railcars and road motor cars, and then to employees in the train operating and commercial services, and the technical and legal departments.

At the present time the application of psychotechnical examinations for the signalmen and pointsmen is under consideration. The above-mentioned categories of staff have to pass a psychotechnical examination before being accepted for employment on the State Railways.

The Czechoslovak State Railway Administration has no laboratory of its own; the psychotechnical examination of the railway staff has been made since the beginning at the Psychotechnical Institution of the Masaryk Work Academy which is now the Central Psychotechnical Institute of Czechoslovakia (UPU). The Ministry of Railways made an agreement with this Institute, according to which a given tax is paid for the different examinations. There is no special Consulting Committee in the Ministry of Railways to deal with psychotechnical examinations, but delegates of the said Ministry take part in the meetings of the Board of the above-mentioned Institute and share in its management as well as in the actual carrying out of the psychotechnical examinations.

The examinations are made either directly in the Institute, or in the various Departments of the State Railways by examiners from the Prague Institute. The examinations are of two kinds : written examinations, which are above all tests, and examinations made by means of special equipment. During its long years of experience with the State Railways, the Central Psychotechnical Institute has elaborated a whole series of completely

satisfactory methods, and made special equipment to carry out the examinations. Before the various obligatory tests are made, orientation tests are made on staff employed by the railway for some time; the results of these tests are compared with the official qualifications of the corresponding staff. As regards actual practice in the matter of examinations, the methods giving the surest results have been adopted, i.e. those most nearly corresponding with the practical results.

The first psychotechnical examinations were made to select drivers, and we will explain the method generally adopted when making such examinations.

The Ministry of Railways has imposed certain regulations on the admission of this category of staff, particularly as regards age and education. For example, the minimum and maximum age is 22 and 28 years respectively. In addition, the candidates must have passed with good results through three grades in the national schools, and have been trained as fitter. After passing the psychotechnical examination, they have to work for at least 2 years in the State Railway shops before being drafted into the locomotive service. They must also pass the prescribed service examinations.

The above shows that a good physical constitution is required to become a driver, as the service is difficult and very tiring; in the first place his senses of sight, hearing and touch must be perfect. The driver or conductor of a vehicle must be able to *concentrate all the time and give his whole attention* to the road in front of him; he must not be distracted from this by any sudden or untoward incident. It is not enough to be calm and collected; it is also necessary to know how to react promptly under all conditions so as to be able to take the necessary steps to avoid accidents.

The driver or conductor must also have a *good memory;* he must remember the routes he works over, the dangerous places, the rising or falling gradients, etc. In the large towns and stations he must be able to remember his way about. It is absolutely necessary that he should be gifted with a certain *pictorial memory :* the engine he has to drive is a complicated one and some of its important parts are not visible from the exterior. To this must be added a special *technical sense :* each candidate should himself be able to carry out the most essential repairs to the engine. Above all drivers and conductors should have *ample intelligence* to be able to remember, understand and apply exactly all the regulations on their duties.

For this reason, in the psychotechnical examinations the greatest attention is paid to examining the *general intelligence* and a special test method is used. This is known as the Yerkes test, and is divided into 8 parts by means of which the general intelligence can be examined from different points of view, such as memory, aptitude for calculation and practical judgment, gift of combination, deduction by analysis, etc.

The candidates examined are given all the tests printed in a special primer; they solve them one after the other, as the examiner tells them, the time allowed for each test being strictly adhered to. All the candidates examined work under the same conditions and the qualification (by marks) is so counted that each test for which an exact solution is given counts as one mark. The total number of tests and consequently the total number of marks that can be gained is 212. The number of marks obtained in the examination can immediately be converted into the intelligence coefficient. According to the diagram drawn up from the practical experience obtained, 24 Yerkes marks correspond, for example, to an intelligence coefficient of 70; IQ = 95 means 80-82 Yerkes

marks; IQ = 110 corresponds to 129-130 Yerkes marks, etc. Experience has shown that the maximum intelligence for drivers oscillates between 90 and 95 IQ.

However we are not content with the Yerkes test when examining the candidates' general intelligence; for check purposes, we make use of another test which gives a very close correlation with the Yerkes test. This has been called the special intelligence test (Bratislava test) so ordered that it includes the same problems as the Yerkes test with the difference that it is possible to solve the easiest and clearest first of all and then pass on to the harder problems, as the solution of the different parts of this test are not given any time limit. This test is particularly advantegeous for those who cannot adapt themselves to the prescribed rhythm of work.

Tests are then made of divided attention and rapidity of reaction; tests of the amount of work done, tests analysing the candidate's ability to estimate distances (space relations) and tests to find out the extent and quality of his memory.

Examination of the way the man's attention is divided, and the rapidity of his reaction, is carried out by means of equipment specialy built in the Central Psychotechnical Institute. The original apparatus consisted of a glass plate divided into three areas each of which in turn was divided up dissymmetrically into little circular areas which could be lit up by different coloured lights. The examinee works according to definite orders given him beforehand. There are five levers in front of him, the three middle ones corresponding to the three main divisions of the plate. If a white light appears in one of the divisions, he has to press down the end lever on the left at the same time as the lever corresponding to the division in which the light appears; if two lights of the same colour appear in two divisions, the candidate has to press down the two corresponding levers. If there are no identically coloured lights nor a white light in any division, he has to press down the end lever on the right side. Formerly there were 13 different combinations in this test; at the present time there are over 50. Obviously this test is also a test of rapidity of reaction, and that under very difficult conditions. Usually the candidate is given 100 tests without any disturbing outside influences, and then 50 with some disturbance. The disturbance consists in attracting the candidate's attention away from the job, or else making him count backwards from 100 to 10 at the same time, or else by giving him another light signal (away from the plate he is watching), to which he must react with the word « stop », or, to give another example, by a siren at the sound of which he must call out « attention ». The kinemographic apparatus registers the accuracy and rapidity of reaction in thousandths of a second. On the bases of the average for a series of 6 different problems to be solved, the marks are given both for the accuracy of the work done and the rapidity with which the candidate reacts.

The chief object of this examination is to find out how the different qualifications of the candidate work together in cohesion. In fact it is not merely a question of examining the rapidity of reaction only, but the accuracy of perception and selection; the candidate must be watched the whole time he is working as the records from the apparatus are not complete in themselves. An exact co-ordination of sensory and motory processes is required of the candidate. If the work is done chaotically and hesitatingly, it is proof that this is not so. A complete proof to the contrary is shown by the candidate being upset, tense, and not understanding the

instructions he is given. A lack on one side can be made up by some other pronounced quality on another, for example a lack of attention can be made good by calmness and reflection.

An examination of the amount of work done is made by means of the Henry dynamograph. The curve of the dynamographic diagram is analysed in particular from the qualitative point of view; diagrams showing regular curves falling slowly show a good output; on the other hand broken up curves prove the opposite.

An examination analysing the candidate's aptitude to judge distances (space relations) is carried out in such a way that the examinees are shown a series of geometrical figures, and have to draw all those only shown for a short time on models on squared paper divided up like the figure shown. Actually the better able a man is to distinguish the proportions of the figures shown, the easier he finds it to remember them, and the more exactly he will be able to reproduce them. The result is based on the number of mistakes.

The simple examination of the extent and quality of the candidate's memory consists of reading out to him two lists of towns, the first being shorter, and the second including all the names in the first with some others; the candidate has to remember, after the second list has been read to him, the names he heard in the first.

Examinations to select railcar drivers are held on the same lines, but with the difference that the standard is not quite so high for general intelligence. Orientation examinations for signalmen have been made in 246 cases altogether. All the signalmen examined had been in railway service at least 3 years and were not more than 40 years old.

After examining their general intelligence and special aptitudes, the results of each examination are arranged in order from the best to the worst. After this the qualifications of each candidate according to the results of the different psychotechnical tests are compared with their service qualifications. To do this, a special questionnaire has been drawn up in which information is sought not only about the quality, successes and failures in work (profession) but also about the peculiarities of character of each candidate. The results obtained show the very close agreement between the practical results and the general intelligence tests. Examinations of special qualities have only a secondary importance, while tests of the candidate's faculty of reaction do not appear to be as important as was thought. We have also paid close attention to certain qualities of character in those examined. Energy, resolution, and calmness are not enough, candidates must also have a sense of responsibility towards the engines and human lives under their care. Irresponsible and careless persons, and those who are confirmed drunkards, even if highly gifted from the point of view of intelligence, must be excluded from railway service. Obviously the candidate must be attentive, orderly in mind and have sense of economy.

Candidates for posts in the *train operating and commercial services* undergo a special system of examination. First of all they are examined from the point of view of general intelligence by test methods, the Yerkes test being also used; the requirements are higher, however. From the experience obtained during several years, the intelligence quota must be at least 110. A certain control test is also used, and a special test (known as the Th-test) by means of which *qualifications required for office work* are examined, as these play a very important part in this branch of the service. In actual fact, this examination consists of a series of 8 tests dealing with the faculty of cencentration, me-

mory, faculty of control, etc., all taking the office requirements into consideration.

To these must also be added two supplementary questionnaires. First of all there is a personal questionnaire of 72 questions to obtain information about the nationality of the candidate and his family, his life and studies, especially at his secondary and higher schools; there are also certain questions the replies to which make it possible to judge of the candidate's opinion of himself. He has to explain his attitude to the different subjects taught at school; explain his success, or if need be his failures; state his private occupations outside his educational interests, as well as the most important cultural influences that have affected his development. We even ask candidates to give themselves marks for aptitude and talents according to a scale of 5 marks. We also require them to give their own characters by asking them what they would have done in certain circumstances, etc. The final questions deal in particular with the candidates' perspective on their own future; we want to know why they wish to enter the railway service.

As far as the candidate's character is concerned, a very important part is played by the supplementary questionnaire known as the *questionnaire of interest*. This questionnaire is divided into 5 parts. The first part deals with various vocations and the candidate has to give his spontaneous and unreasoned opinion on each of these vocations. The second part deals mainly with his theoretical interest in various cultural questions. The third part gives several pairs of contrary occupations, for example : intellectual work — manual work, and the candidate has to choose between them. The fourth part contains questions to find the candidate's subjective attitude towards people and things. The fifth and last part contains questions on the habits, dispositions and experience the candidate has acquired.

At the present time a statistical enquiry is in hand to discover how far the psychotechnical results agree with the service results. From the experience obtained up to the present the coefficient of relation between the two is about 85 %.

From the psychotechnical point of view it is very important *to analyse the causes of railway accidents and mishaps* in so far as they are due to the human factor; for this reason men who have caused an accident or mishap are sent to the Central Psychotechnical Institute where they are given a very detailed examination from the psychotechnical and medical points of view. The Czechoslovak State Railway Administration has not drawn out any statistics up to the present showing the resulting decrease in the number of accidents, illness, etc.; but it intends to do this in the near future.

Candidates for the train operating, commercial, technical and legal services do not have to pass any written examinations.

About 2 000 men can be examined annually in the Central Psychotechnical Institute. Up to the present this figure has never been reached.

| | | | | |
|---|---|---|---|---|
| In | 1928, | 1 447 | persons | were examined. |
| » | 1929, | 1 610 | » | » |
| » | 1930, | 400 | » | » |
| » | 1931, | 634 | » | » |
| » | 1932, | 166 | » | » |
| » | 1933, | 156 | » | » |
| » | 1934, | 224 | » | » |
| » | 1935, | 830 | » | » |

The way employees carry out their duties is checked, and the service results compared with the results of the psychotechnical examination.

After the examination has been made, the Special Committee classify the results under four headings : very good, good, fair, insufficient.

The lowest limit for the candidate to be accepted is fair.

As only candidates wishing to obtain employment on the Czechoslovak State Railways undergo psychotechnical examination, the cost depends on the number of recruits and examination staff and varies beween 5 000 Kc and 35 000 Kc a year. In 1936 the cost was 24 900 Kc.

The Czechoslovak State Railway Administration has no staff entirely employed in making psychotechnical examinations. As stated above, the examinations are made by the Central Psychotechnical Institute with the assistance of delegates from the Ministry of Railways.

The Czechoslovak State Railway Administration does not contribute to the cost and maintenance of the Central Psychotechnical Institute; as far as we know the average expenditure of this Institute is 20 000 Kc a year on the average.

*Psychotechnics applied to the training of the staff.*

Up to the present psychotechnics have not been applied on the Czechoslovak State Railways to professional training, as they own no laboratories for this purpose.

*Professional orientation.*

Professional orientation has not been introduced on the Czechoslovak State Railways.

*Education of the railway staff.*

There are no schools for the children of employees and no Sunday or night-school courses are subsidised by the railway; nor are there any railway training schools.

The training of employees takes place according to the special service regulations, i.e. by means of special lectures, or else in the schools on the basis of special training for the category of staff in question. In addition newly recruited employees are sent to suitable places in order to receive practical training in their duties.

*The Czechoslovak State Railways organise classes* for nearly all categories of staff. These classes are usually short courses of 2 to 3 months; there is a special instruction programme for each course. The class hours differ according to the category of staff for which the course is held. At the end of each course the employees attending it have to pass a final examination. In the case of higher grades of staff (train operating and commercial) there are *special schools* which last at least *two months* and give detailed instruction on the subjects in question.

Specialists are appointed to give the instruction in these courses and schools; in the first place employees known as « schoolmen » (instructors) are chosen, and then employees from headquarters.

The training and improvement of young employees takes place according to school methods, i.e. the subject is dealt with and revised in the ordinary scholastic fashion. Examinations are likewise held as in the schools.

There is no methodical organisation to train higher-grade staff and railway specialists.

As we said above, for each course and school a special instruction programme has been drawn up; the length of the course depends upon the end in view. The shortest courses give some 80 hours training; the most important courses about 300 hours, and the railway schools from 200 to 800 hours training.

The rule that not more than 6 hours instruction a day shall be given in the schools is always kept.

The expenditure on these classes is divided up between the Czechoslovak State Railway Administration and its employees; this division can be explained by the fact that both the parties concerned profit to some extent from the organisation of these classes.

There are no private or official technical schools to train railway specialists.

*Experience up to the present has shown that the results of the training given in these schools is satisfactory for the railway.*

**JUGOSLAVIA. — Jugoslav State Railways.**

Length of lines in operation at the end of 1935 : 9 370 km. (5 822 miles).

Total strength of staff : about 72 000 employees including labourers.

*General information.*

The Subotica locomotive and rolling stock division was the first, in its 1920 scheme on professional schools to train qualified workmen, to point out the need for *selecting* candidates for these schools from the shops, by *psychotechnical methods.*

*The practical application of psychotechnical methods* was first made in 1926 to choose candidates for the technical school of the Zagreb shops. Apart from this school, psychotechnical methods of investigation are not used officially.

There is no psychotechnical laboratory; for the psychotechnical examinations in the technical school only tests which do not require any special laboratory equipment are used.

For the moment only candidates for the Zagreb shop schools have to pass psychotechnical examinations.

As for the other branches of the service, the selection of candidates is based on their general education and a medical examination to find out their physical state : sight, hearing, ability to distinguish colours, and general state of health.

The professional training and improvement of newly recruited staff in the different branches of the service is carried out by means of various courses.

Statistical data relating to the number of employees examined between 1926 and 1935 relating to the Zagreb shops training school are as follows :

| *Year* | *1926* | *1927* | *1928* | *1929* | *1930* | *1931* | *1932* | *1933* | *1934* | *1935* | *Total : 1926 to 1935* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Candidates | 121 | 124 | 102 | 114 | 121 | 40 | 61 | 108 | 161 | 288 | 1 240 |
| Admitted | 31 | 28 | 32 | 35 | 32 | 28 | 41 | 20 | 20 | 40 | 307 |

The results of the tests are worked out every year according to the quality of the answers and the time taken; the marks are given as a percentage of the best answer given in the shortest time during that year's examinations.

When the final summing up of the candidate's aptitudes is being made, the importance of each test is taken into consideration as well as the marks obtained for the different tests.

In addition to the psychotechnical results obtained by each candidate, his physical state and general education is also taken into account before admission. Except in 1931 and 1932, when the number of pupils required was twice as great as the number of candidates, admission has been limited to candidates obtaining at least 70 % of the marks.

In the Zagreb shops the correlation coefficient is reflected by the constant admission of candidates according to the psychotechnical results obtained.

It has been objected that the psychotechnical examination depends not only on the aptitude of the candidates but also on his mood during the examination. This was clearly appreciated from the very beginning, but the necessity for examining a very large number of candidates in a relatively short time makes it impossible to study the aptitude of candidates taking into account their momentary disposition.

In the above mentioned school, a certain number of tests have been instituted to find out in a general way the aptitude of the candidates for the various

trades. There is no special expenditure on the psychotechnical examinations.

*Professional orientation* on a psychotechnical basis has not been introduced up to the present.

*Training of railway staff.*

There are no special day or night schools for the children of employees.

Together with the professional training in the technical school at the Zagreb shops, a general education is also given.

The Jugoslav State Railways have organised schools and instruction courses to train specialists in the different branches of the service (Train operating — permanent way — locomotive running — shops).

These classes are given by specialists from the corresponding services as far as the professional training is concerned; the general education is given by teachers from other schools.

The education in the technical schools to train skilled workmen lasts 4 years; that in the Jugoslav State Railways' national school, 2 years, while the different courses last from 2 months to one year.

Tuition in all the schools and classes is free.

The results obtained in the different schools and railway classes has been found satisfactory for the railway services.

## SUMMARY.

From the replies received we have been able to draw up the following conclusions :

It would be advisable for the 1937 International Railway Congress to recommend :

1. That the Governements of all countries as well as all the Railway Administrations should use and apply psychotechnical methods in their public and private transport services.

2. That the accident statistics be scientifically organised. The information given by the various Railway Administrations shows that when psychotechnical methods are applied the number of accidents diminishes.

3. That there be international collaboration of the psychotechnical experts of the railways in order to standardise the psychotechnical methods (standardisation of tests, etc.), used on the different Railways.

4. That the development of regular and methodical training of staff for the various branches of the railway service be supported and helped as far as practical.

[ 656. 222 1 ]

# Note on Train Speeds,

by Lionel WIENER,
Professor at the University of Brussels.

## PART II *(Continued)* [1]

## Train speeds and services in different countries.

## XIX. — SPAIN AND PORTUGAL.

SUMMARY.

CHAPTER L.

1. The railway systems.
2. Track- and loading gauges.
3. « De luxe » trains, sleeping- and restaurant-car services.
4. Electric traction.
5. Railcars.
6. Trains and speeds.

L-1. — **The Spanish railway system** includes 12 392 km. (7 700 miles) of broad-gauge lines belonging to 5 major and a number of minor Companies, and 4 271 km. (2 654 miles) of metre-gauge lines. **The Portuguese system** also includes lines of both gauges (2 726 and 719 km., i.e. 1 694 and 447 miles), mainly worked by the *Portuguese Railways Company.*

The lines belonging to the various Companies are more entangled than in other countries, and like the *Paris-Orléans'* tentacular line extending into the *State* preserve as far as Pornic, the *Norte* owns a long line running from Tarragona, south of Barcelona, as far as Valencia and La Encina, which complicates the Valencia-Barcelona and Valencia-Madrid services.

The Spanish lines radiate from Madrid towards the coast, dividing up, if need be, to serve the chief ports. The montainous nature of the country made their location particularly difficult as the interior of the country is a high plateau with mountain ranges. In consequence, many lines climb to a thousand metres above sea level before being able to run down to the coast (figs. 350, 351 and 352). The Madrid-Irun line reaches 1 300 m. (4 265') above sea level (La Cañada is

(1) Cf. *Bulletin of the Railway Congress*, October and November 1933; January, May, June and July 1934; February, March, April, May, July and October 1935; March, May, June, July and August 1936.

Fig. 350. — Crossing the Orduña pass. — Descent towards the sea of the Castejon-Bilbao line *(Norte Ry.*, Izarda-Luyando section).

1 358 m. = 4 455′ above sea level) (1) a great contrast with the easy line to the north of the Pyrenees (fig. 353). This helps to explain the difference in train speeds on either side of the frontier. Many other lines climb 1 100 to 1 200 m. (3 609′ to 3 937′) above sea level (2) as do, of course, the new transpyrenean lines which reach higher altitudes than do the transalpine railways.

---

(1) On the NORTE's main lines, the following stations are over 1 000 m. (3 280′) above sea level :

*Madrid-Hendaye line* (via Avila) :

| | | | |
|---|---|---|---|
| Robledo | 1 014.70 m. (3 329′) | Navalgrande | 1 311.78 m. (4 304′) |
| Santa Maria | 1 167.63 m. (3 831′) | Guimorcondo | 1 153.78 m. (3 785′) |
| Las Nevas | 1 218.95 m. (3 999′) | Avila | 1 131.12 m. (3 711′) |
| Nevalperal | 1 274.80 m. (4 182′) | Pedrosillo | 1 104.22 m. (3 623′) |
| La Cañada | 1 358.16 m. (4 456′) | Mingorria | 1 068.24 m. (3 511′) |

*Villalba-Medina line* (via Segovia) :

| | | | |
|---|---|---|---|
| Collado-Mediano | 1 012.70 m. (3 322′) | El Espinar | 1 202.52 m. (3 945′) |
| Los Molinos | 1 063.85 m. (3 490′) | Otero | 1 220.00 m. (4 003′) |
| Cercedilla | 1 166.66 m. (3 827′) | La Losa | 1 115.47 m. (3 660′) |
| San Rafael | 1 249.86 m. (4 100′) | Segovia | 1 008.32 m. (3 308′) |

(2) The CENTRAL DE ARAGON Railway reaches the following altitudes :

*Caminreal-Saragossa line :*

| | | | |
|---|---|---|---|
| Ferreruela | 1 027 m. (3 369′) | Cuencabuena | 1 002.50 m. (3 289′) |

*Calatayud-Valencia line :*

| | | | |
|---|---|---|---|
| El Puerto de Escandon | 1 218.40 m. (3 997′) | La Puebla de Valverde | 1 165.00 m. (3 822′) |
| Cella | 1 012.43 m. (3 321′) | | |

The NORTE's other lines area as badly off; thus Brañueles, on the Palencia-Coruña line, is 1 050 m. (3 445′) above sea level.

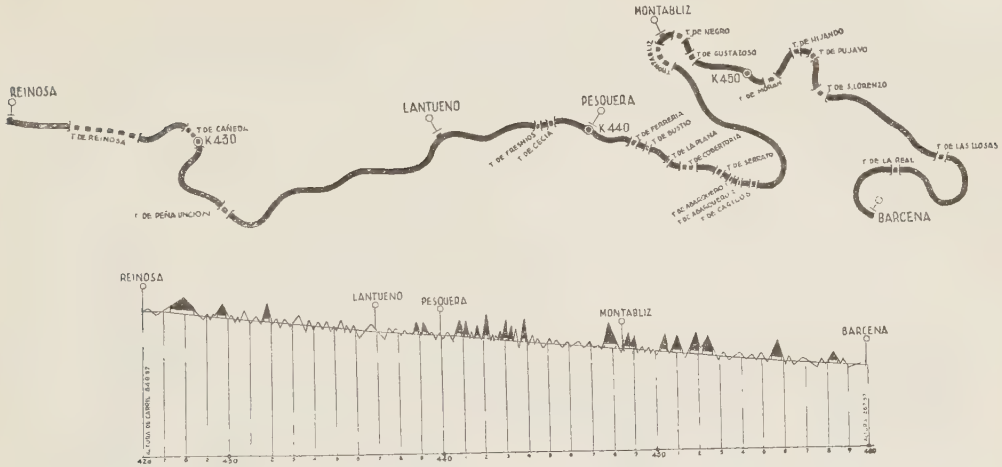



Fig. 351. — Reinosa-Barcena section of the Venta de Baños-Santander line, *Norte Ry.*

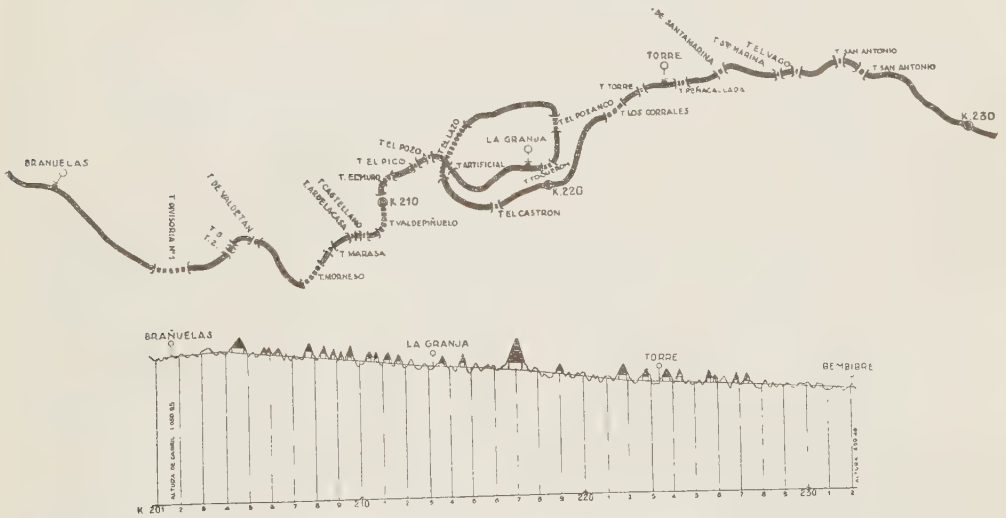



Fig. 352. — Manzanal Pass location, Palencia-La Coruña line, *Norte Ry.*

As the traffic was insufficient to make the railways pay, expensive works had to be avoided. Moreover, most of the main lines are old and the result of amalgamation of several separate sections originally worked by local companies. Thus the *Norte*'s (Northern Railway's) main line includes the originally independent *Madrid-Valladolid, Valladolid-Burgos* and *Burgos-Irun Railways;* after having linked them up, their drawbacks as a through traffic medium became apparent.

Investigation of shorter routes was then undertaken, beginning with the

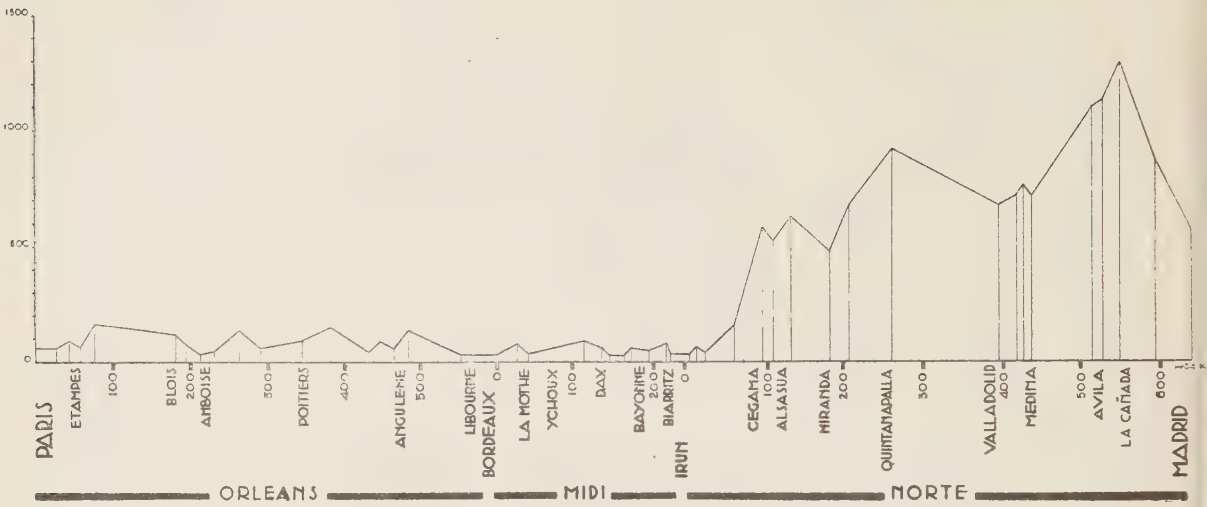



Fig. 353. — Gradient section of the Paris-Madrid line.
Horizontal scale : 1/6 000 000, vertical scale : 1/20 000.

worst lines, those from Madrid to Valencia and from Madrid to Seville. Thus from Madrid to Valencia, the distance now is 490 km. (304.5 miles) via Chinchilla, whereas it is but 294 km. (182.7 miles) as the crow flies. A less roundabout route might make use of two existing lines which are in operation at either end, from Madrid to Cuenca (201 km. = 124.9 miles) and from Utiel to Valencia (88 km. = 54.7 miles). This leaves a gap of but 113 km. (70.2 miles) along which a railway is being built, thus reducing the entire distance to but 402 km. (249.8 miles). Offsetting this advantage is the fact that the line would be a difficult one particularly at its eastern end.

Similarly, the Madrid-Seville line is 573 km. (356.1 miles) long via Baeza, while the construction of a 115-km. (71.5 miles) railway between Puertollano and Cordoba would bring Seville within 458 km. (284.6 miles) from Madrid (1).

**International communications** are only possible with France and have existed since 1864, west of the Pyrenees, via Irun and Hendaye, and since 1878, east of them, via Port Bou-Cerbère. As the distance between them is considerable, the *Norte* has built two intermediate transpyrenean lines : from Barcelona to Puigcerda-La Tour de Carol towards Toulouse and from Saragossa to Canfranc towards Pau. In spite of the high altitudes they reach (2), moderate-speed expresses are run, but so far no important international trains are routed along them, as it is difficult — as formerly in the case of the *Bern-Lötschberg-Simplon Ry.* — to divert existing traffic currents.

(1) The distance from Madrid to Puertollano is 212 km. (131.7 miles); that from Cordoba to Seville is 131 km. (81.4 miles).

(2) Canfranc is 1 194 m. (3 917′) above sea level and, though Puigcerda is only 1 146.64 m. (3 762′) above sea level, the railway had to proceed via La Molina, at 1 420.22 m. (4 659′) above datum, in order to reach it.

Fig. 354. — Cartogram of the maximum average speeds of the Iberian express trains. The lines corresponding to different speeds are the same as those previously used for such cartograms. Places served by non-stop trains from Madrid are underlined.

A third intermediate transpyrenean railway, from Lerida to Saint-Girons, through the Salau Pass, is unfinished.

Along the western frontiers, five Spanish international lines run into Portugal, two of them being used for Luso-French connections transiting through Spain. The oldest of these runs from Lisbon to Irun via Madrid and the newer, and more direct one, utilises 203 km.. (126.1 miles) of the *Portuguese Rys. Co.* and 202 km. (125.5 miles) of the new *Spanish Western* from the frontier until its junction with the previous line at Medina del Campo.

This survival of the old conditions when local companies only built sections of line and not complete railway systems has its parallel in Holland where international routes used the lines of the obsolete *Central Nederland* and *Noord Braband* Railways, and in Belgium, in the case of the 61-km. (37.9 miles) section of the *Nord Belge*, on the Paris-Berlin main line.

L-2. — **Track- and loading gauges.** — The 1.674-m. (5′ 6″) gauge was not adopted, as is generally thought, for strategic reasons, so as to introduce a break of gauge at the Franco-Spanish frontier. It

was deliberately chosen on the recommendation of the 1844 Commission which, after having investigated the *Great Western Ry.*'s 7-ft. gauge, the *Eastern Counties'* 5-ft and the first Russian (1) and Irish Railways' 6-ft. (since reduced to 5′ and 5′ 3″ respectively), decided in favour of a standard gauge of two « varas » (i.e., 6 Spanish ft. or 1.674 m.), for the whole Iberian Peninsula.

Like everywhere else, when the drawbacks of transhipment at the frontier became apparent, it was deemed necessary to obviate it and it was considered in turn whether it would be more advisable to alter the gauge of the whole system or to build a standard-gauge line from Irun to Algeciras only, via Madrid (2).

The length of a more direct line from Irun to Madrid varies from 440 km. (273.4 miles) (Government proposal) to 417 km. (259.1 miles) *(American International Corporation* scheme), while the existing line is 663 km. (412 miles) long. All these plans have of course been shelved indefinitely.

It would seem that owing to the greater width of the Iberian track gauge (fig. 355), the width and capacity of the vehicles should be greater than those of the European standard gauge lines, the 7 1/2 inches difference in gauge allowing some 16 inches overhang, but this is not the case; in fact, the Spanish rolling stock is in many instances smaller than standard-gauge stock.

Thus, the usual dimensions of Spanish dard-gauge stock.

| | |
|---|---|
| Inside width. . . . | 2.805 m. (9′ 2 53/64″) |
| Inside length . . . | 6.43 m. (21′ 1 5/32″) |
| Inside height . . . | 2.495 m. (8′ 2 1/4″) |

Their volume is 39 m³ (51 cu.yds), as against 45 m³ (58.8 cu. yds) of the standard-gauge. Until recently, the same applied to passenger stock. A carriage with a 20-m. (65′ 7 3/8″) body was only 2.80 m. (9′ 2 1/4″) wide (on the Asturias line) or 3.12 m. (10′ 2 53/64″) on the main lines, which is no more than our own.

This was due to the constitution of the railway and the economic conditions of the country. The cuttings and tunnels of the older lines were too narrow; the Spanish six-foot way is actually only 2 m. (6′ 6 3/4″) whereas in these parts it is 2.08 to 2.10 m. (6′ 9 29/32″ to 6′ 10 43/64″). This limits the width of the cars. And their height was affected by the large diameter of the wheels which was 1.06 m. (3′ 5 3/4″), apart from building gauge restrictions.

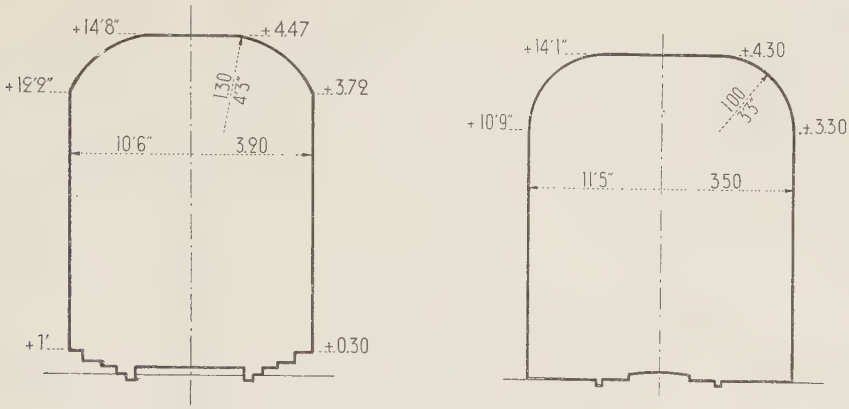
---

(1) This was the *St. Petersburg-Pavlovsk Railway* conceded by Czar Nicolas, on 21st March 1836, whose first section (Pavlovsk to Tzarskoié Selo) was opened to traffic with horse-drawn vehicles on the 9th October, and with steam traction on 22nd November 1836; the remaining section from Tzarskoié Selo to St. Petersburg was opened on the 30th October 1837.

(2) There are but a few small sections of standard-gauge line :
11 km. (6.8 miles) of the *Sarria Barcelona Ry.;*
46 km. (28.6 miles) of the *Cataluña Ry.;*
44 km. (27.3 miles) of the *Langreo en Asturias Ry.* (1.45 m. = 4′ 9″).

The 19.141 km. (11.893 miles) of the *Madrid Metropolitan* are 1.445 m. (4′ 8 29/32″) gauge and the 4.5 km. (2.8 miles) of the *Gran Metropolitano de Barcelona* are broad gauge; the 6 km. (3.7 miles) of the *Metropolitano de Barcelona* are 1.435-m. (4′ 8 1/2″) gauge.

As regards other gauges, the 23 km. (14.3 miles) of the *Goldames e Sestao*, are of 1.16-m. (3′ 9 43/64″) gauge: In Marjorca, there are 181 km. (112.5 miles) of 3′ gauge lines (fig. 354).




Norte.
5′ 6″ gauge.

Madrid, Zaragoza y Alicante
5′ 6″ gauge.

Fig. 355. — Loading gauges of the chief broad-gauge railways.
(The new gauge of the *M.Z.A.* is shown in fig. 357.)

On the other hand, economic factors obliged Spain to use vehicles having the same overall dimensions (save as regards their height, owing to the diameter of the wheels) as the other Continental ones. As until 1914, the Companies could import their stock free of duty, most of the vehicles came with standard gauge axles or trucks from Germany, Belgium or France, and were adapted to the Spanish gauge at the frontier.

It is true, each individual Company had its own loading gauge (fig. 356) but it differed very little from the others.

Since the outbreak of the War, rolling stock has been manufactured in Spain, which enabled the Railway Companies to increase their loading gauge. The *Madrid-Saragossa-Alicante Railway (M.Z.A.)* led the way by increasing the width of its cars by 10 cm. (3 15/16″) and the height at the centre by 40 cm. (16″). The *Northern (Norte)* followed, and when electrifiying the Asturias line, altered the loading gauge, thus doing away with the chief restriction affecting its rolling stock.

In order to appreciate the importance of these improvements, we quote the superficy of some of the Spanish loading gauges and of French ones in communication with them, and also of their relative sizes, taking the minimum French loading gauge as unit :

| | | |
|---|---|---|
| *Spanish loading gauges :* | | |
| *M.Z.A.*, before 1929. | 14.57 m² (156.8 sq.ft.) | 1.24 |
| *M.Z.A.*, since 1929. | 15.47 m² (166.5 sq.ft.) | 1.32 |
| *Norte* . . . . . | 13.45 m² (144.8 sq.ft.) | 1.14 |
| *French loading gauges :* | | |
| *Midi Ry* . . . . | 13.00 m² (139.9 sq.ft.) | 1.11 |
| *P.O. Ry* . . . . | 12.42 m² (133.7 sq.ft.) | 1.06 |
| Minimum gauge . | 11.75 m² (126.5 sq.ft.) | 1.00 |

This made it possible to increase the width of recently built Spanish stock to the following dimensions :

*Norte :* 2.945 m. (9′ 8″) Asturias line;
3.150 m. (10′ 4″) suburban services;
3.196 m. (10′ 5 53/64″) recent stock.

*M.Z.A. :* 3.045 m. (9′ 11 29/32″) luxury stock;
3.130 m. (10′ 3 1/4″) suburban services.

*Andaluces :* 3.170 m. (10′ 4 53/64″).

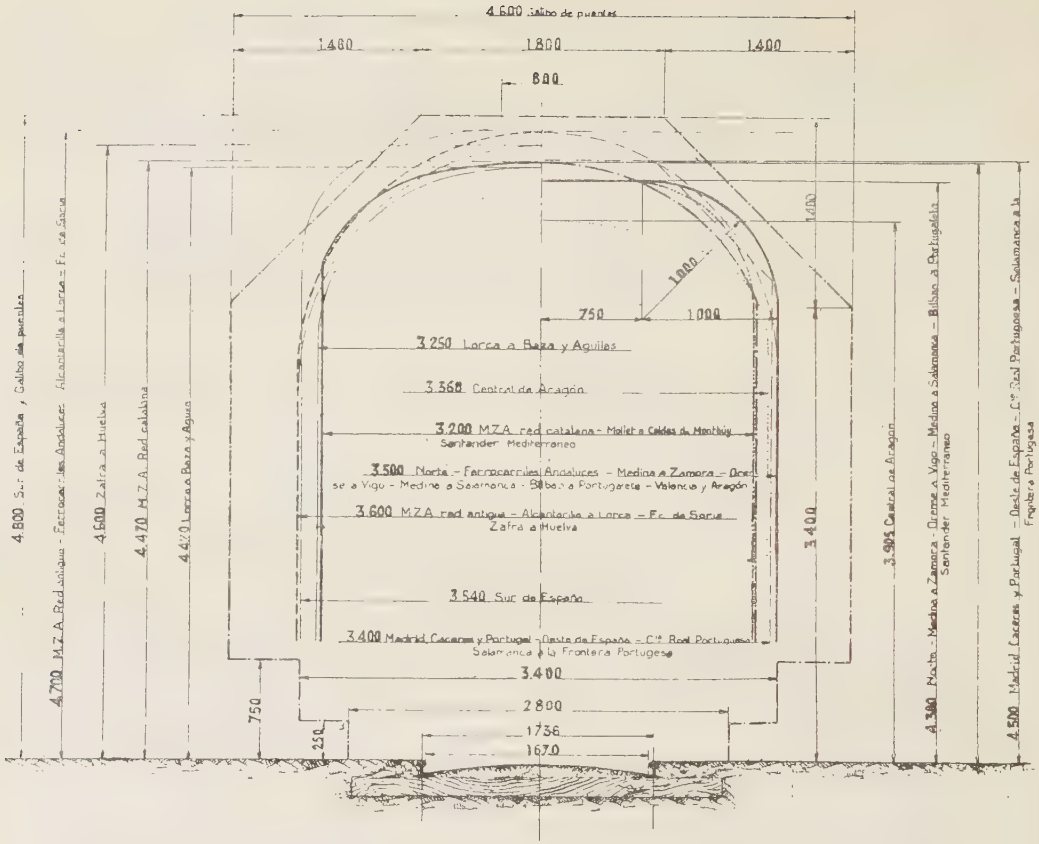

4.600 Galibo de puentes
1.400
1.800
1.400
800
1.400
1000
750
1000
3.250 Lorca a Baza y Aguilas
3.568 Central de Aragón
3.200 M.Z.A. red catalana - Molet a Caldes de Monthuy
Santander Mediterraneo
3.500 Norte - Ferrocarriles Andaluces - Medina a Zamora - Orense a Vigo - Medina a Salamanca - Bilbao a Portugalete - Valencia y Aragón
3.600 M.Z.A. red antigua - Alcantarilla a Lorca - Fc. de Sarria
Zafra a Huelva
3.540 Sur de España
3.400 Madrid Caceres y Portugal - Oeste de España - C.ª Real Portuguesa
Salamanca a la Frontera Portuguesa
3.400
2800
1736
1670
750
250
4.800 Sur de España y Galibo de puentes
4.700 M.Z.A. Red antigua - Ferrocarriles Andaluces - Alcantarilla a Lorca - Fc. de Sarria
4.600 Zafra a Huelva
4.470 M.Z.A. Red catalana
4.470 Lorca a Baza y Aguas
3.400
3.906 Central de Aragón
4.300 Norte - Medina a Zamora - Orense a Vigo - Medina a Salamanca - Bilbao a Portugalete
Santander Mediterraneo
4.500 Madrid Caceres y Portugal - Oeste de España - C.ª Real Portuguesa - Salamanca a la Frontera Portuguesa

Fig. 356. — Comparative loading gauges of the Spanish and Portuguese Railway Companies working 5′ 6″ gauge lines.

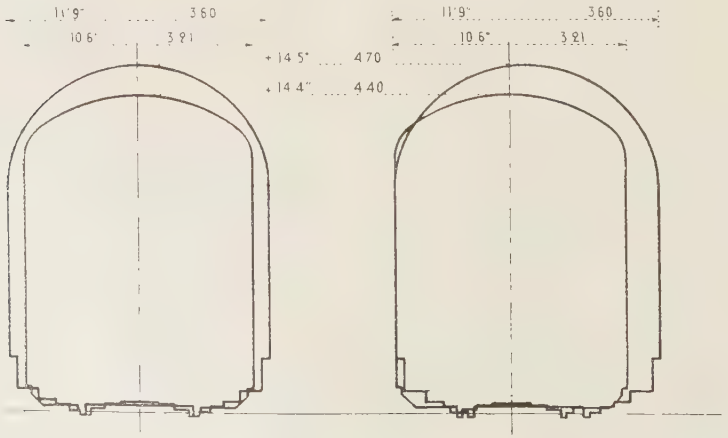



Fig. 357. — Comparison of the area of a French Company's *(Midi)* loading gauge (standard gauge track) with that of a Spanish Company *(M.Z.A.)* (5′ 6″ track).

We also give in figure 358, as a matter of information, the loading gauge of a Spanish metre-gauge line (*Vascongados Ry.*).

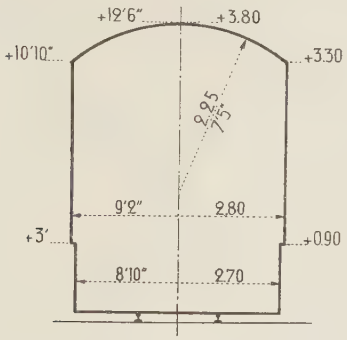



Fig. 358. — Loading gauge of the *Vascongados Ry.* (metre gauge).

L-3. — **The International Sleeping-Car Company's Iberian services** include « de luxe » trains and sleeping-car services (fig. 359) besides restaurant- and Pullman-car services.

International Franco-Spanish services have for a long time run into Spain at the western and eastern ends of the Pyrenees, but no new services have as yet been run over the new lines. In all cases, owing to the difference in gauge, transhipment is necessary at the frontier and all Spanish trains are therefore internal ones.

The Sud-Express (1), one of the chief and also one of the oldest « de luxe » trains, was projected at the same time as the « Orient Express » and was to run as the « Nord-Sud Express » from St. Petersburg to Lisbon. Various circumstances and in particular the great epidemics which ravaged the south of Europe at that time, hindered the scheme, so that it was not until the 5th November 1887 that its southern section was introduced under the name of « Sud Express » to link up Paris and Lisbon, via Irun and Madrid. As the agreements with the *Norte* had not been completed, the two end portions alone — from Paris to the Spanish frontier, and from Madrid to Lisbon — were first started. However, the « Sud Express » was soon running all the way, and since the 1st June 1896, the Lusitanian traffic became important enough to justify the doubling of the train at Medina del Campo, one rake running to Madrid and the other directly to Lisbon, saving 193 km. (119.9 miles) on this run. For some time the latter portion included through coaches to Oporto which arrived at about the same time as the rest of the train at Lisbon.

The Madrid rake was tentatively extended from time to time, but such experiments never lasted long. For a time, it ran weekly to Algeciras in connection with the Gibraltar and Morocco boats. At another period it was extended to Alicante whence boats left for Oran.

At Pampilhosa, the Portuguese rake picks up an Oporto Pullman and the train is now extended a further distance of 27 km. (16.8 miles) accomplished in 27 minutes, as far as Estoril. This is an extension similar to that of the Bucharest-Constanta Pullman to Carmen Silva, beyond Constanta. The Lisbon « Sud Express » service is complicated by the fact that it runs over several local Companies' lines, though from Medina del Campo to the Portuguese frontier, it remains on the lines of the newly formed *Nacional del Oeste* Company. Until recently these 134

(1) Two « de luxe » trains only were older : the « Orient Express », had been introduced on the 5th June 1883 and the « Calais-Nice-Rome Express », forerunner of the « Paris-Rome », dates from the 8th December 1883. The « Méditerranée Express » is more recent, and dates from 1889 only.

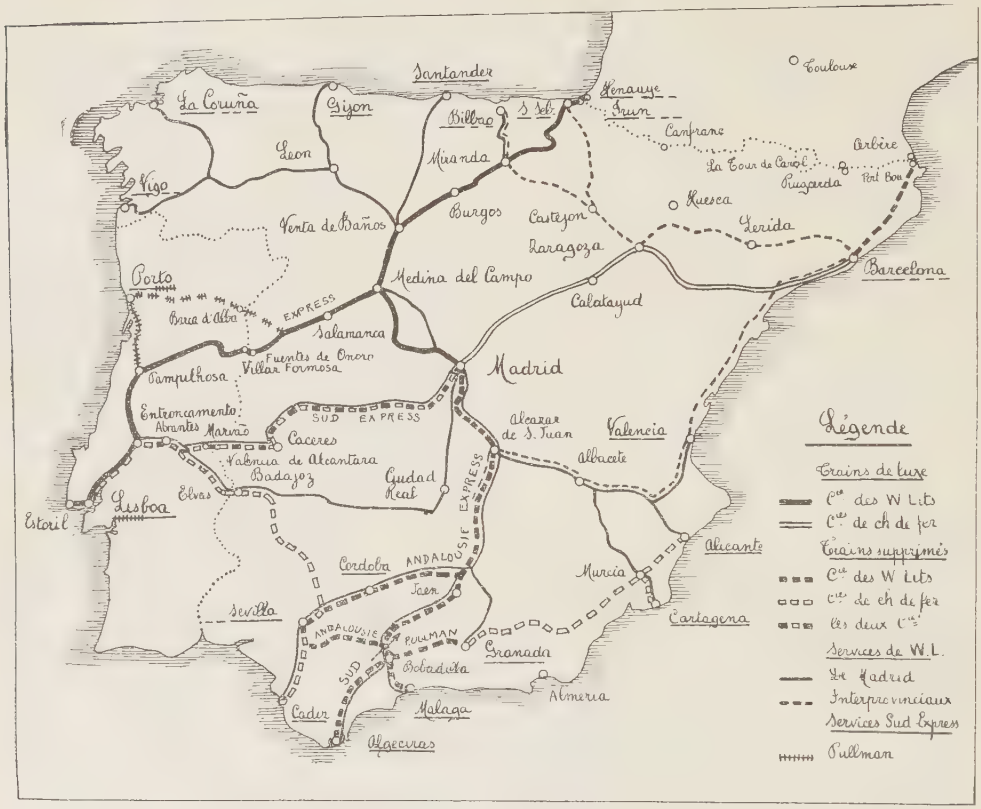



Fig. 359. — Iberian « de luxe » trains and services of the *International Sleeping-Car Company*.
Termini of sleeping-car services from Madrid are underlined.

km. = 83.3 miles) belonged to two small distinct companies, the *Medina del Campo-Salamanca* and the *Salamanca a la Frontera* Railways. These same situation occurs in Portugal where, to reach the main line of the *Portuguese Rys.*, it proceeds over 203 km. (126.1 miles) between the frontier and Pampilhosa, of the *Beira Alta Railway*.

Even the extension beyond Lisbon belongs to a small independant Company, the *Estoril Ry. Co.*

Since the « South Express » abandoned the Madrid-Lisbon line, the owning railway Companies introduced between the two Capitals, a « de luxe » train with a Cadiz-Seville and Badajoz branch.

The « Andalusian Express » of pre-war days was a day « de luxe » train maintained between Madrid and Seville.

In those days there was an *Andaluces* « de luxe » train whose two portions linked up Seville on the one hand with Granada and Malaga on the other. Since 1929 an « Andalusian Pullman Express » has replaced it, and since the crisis has itself been displaced by a railway company's express.

TABLE 297.

INTERNATIONAL SLEEPING-CAR COMPANY'S SERVICES IN SPAIN AND PORTUGAL AND « DE LUXE » TRAIN SERVICES RUN BY THE RAILWAY COMPANIES.

*Obsolete services are shown in italics* (fig. 359).

| RUN. | Distance. | | Time of departure. | Time spent. | Speed. | | — |
|---|---|---|---|---|---|---|---|
| | Km. | Miles. | | | Km./h. | Miles/h. | |
| *Port-Bou-Barcelona* | 167 | 103.8 | *8.23* a m. | *3.47* | *44.1* | *27.4* | « Paris-Barcelona » Express. |
| *Irun-Medina del Campo-Madrid-Lisbon* (1) | 1 296 | 805.3 | *7.35* a.m. | *31.40* | 40.9 | 25.4 | « Sud Express » |
| Irun-Medina del Campo-Madrid | 631 | 392.0 | 8.35 p.m. | 13.40 | 46.2 | 28.7 | Do. (15 stops). |
| Irun-Medina del Campo-Estoril-Lisbon | 1 103 | 685.4 | Do. | 21.05 | 52.3 | 32.5 | Do. |
| *(Irun) Pampilhosa-Oporto* | 111 | 69.0 | *4.40* a.m. | *2.45*(2) | *40.0* | *24.9* | Do. (pre-war). |
| Oporto-Lisbon | 343 | 213.1 | 1.00 p.m. | 4.48 | 71.5 | 44.4 | Isolated Pullman car. |
| *(Irun) Madrid-Alicante* | 455 | 282.7 | ... | ... | ... | ... | *Sud Express.* |
| *Madrid (Atocha)-Seville.* | 573 | 356.0 | *10.40* p.m. | *11.00* | *52.1* | *32 4* | *Andalusia Express.* |
| *Seville-Granada* | 288 | 179.0 | *8.00* a m. | *7.15* | *39.7* | *24.7* | *Andalusia Pullman. Express.* |
| *(Seville) Bobadilla-Malaga* | 70 | 43.5 | *12.08* p.m. | *1.22* | *51 2* | *31.8* | *Do.* |
| RAILWAY COMPANY « DE LUXE » TRAINS. | | | | | | | |
| Madrid-Saragossa-Barcelona, first train | 685 | 425.6 | 8.00 p.m. | 13.30 | 50.7 | 31.5 | Expreso lujo 802. (28 stops). |
| Do. second train | Do. | Do. | 10.15 p.m. | 11.41 | 58.7 | 36.4 | All-sleeping-car train (six stops). Expreso lujo 804. |
| *Granada-Murcia-Alicante or Cartagena* | ... | ... | ... | ... | ... | ... | See table 299. |
| *Lisbon-Torre des Vargens-Madrid (Atocha)* | 665 | 413.2 | *4.22* p.m. | *16.12* | *41.5* | *25.8* | *« de luxe » train.* |
| *(Lisbon) Torre des Vargens-Badajoz (Cadiz).* | 108 | 67.1 | *8.34* p.m. | *2.56* | *36.8* | *22.9* | *Do.* |

(1) Departure from Paris at 6.53 p.m. : 16-minute stop at Madrid.
(2) Arrival at Oporto 2 minutes after the hour of arrival at Lisbon.

The PARIS-BARCELONA EXPRESS was introduced in 1906. Re-introduced after the War under the name « Barcelona Express », it is made up in France of *International Sleeping-Car Co.* stock attached to a *Paris Orléans-Midi* train, and between Port-Bou and Barcelona is extended by means of an ordinary express including a single Pullman coach.

« **De luxe** » **trains run by the Railway** to a *Paris Orléans-Midi* train, and bet-

among the few countries to own such trains, with both day and night services.

Thus there was, before the War, a « de luxe » train from Lisbon to Madrid, with an extension to Badajoz, Seville, and Cadiz. This has now been replaced by an ordinary express.

The Seville-Granada service has been dealt with in the same way.

However, the *M.Z.A.* still runs two « de luxe » trains linking up Madrid with Barcelona, the second of which, made up of sleepers only, leaves Madrid two hours after the first.

In addition, this railway owned restaurant- and saloon cars, and the *Andaluces* Company now taken over by the State, had Pullman cars which have been bought up by the latter.

**Sleeping car-services.** — For many reasons, the chief express trains run at night. Madrid is thus linked up by sleeping-car trains with the important harbours. Where the lines fork, the sleepers are alternatively run along either of them or, when traffic is sufficiently important, the train carries rakes for both (1).

From Lisbon, there is a sleeping-car service to Oporto which takes 9 h. 27 m. to cover the 349 km. (216.9 miles). It belongs to the class of trains which are timed slowly to as to enable passengers to enjoy a long night, even between places near together such as Brussels and Paris (311 km. = 193.3 miles), Vienna and Budapest (285 km. = 177.1 miles), Paris and Calais (via Lille) in former days, and the new Paris and London 11-hours service.

Apart from these services, sleeping cars belonging to the railway Companies, are also run. Those of the *M.Z.A.*, for example, are used to make up the Madrid-Barcelona « de luxe » trains, in which an extra charge, based on mileage as on the *International Sleeping Car Co.*'s services, has to be paid.

The first *International Sleeping Car Co*, Russian broad-gauge stock was built in 1880 and the first Spanish, in 1883. The latter made the fullest possible use of the loading gauge, the width of the carriages being 3.25 m. (10′ 8″) instead

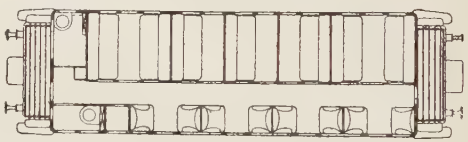


Fig. 360. — Old six-wheeled sleeping car, built in 1883.
The scale of this diagram is the same as that of all similar diagrams previously reproduced.

of the 2.85 (9′ 4 13/64″) of the standard-gauge stock, a width which has never again been reached. The corridor was wide enough to accomodate 8 seats which added four berths to the 14 permanent ones. Except for the 1885 sleeping cars, these were the Company's last six-wheeled coaches.

The present-day stock differs very little from that for standard gauge; thus the Pullman bodies built in England were sent to Hendaye on standard-gauge trucks and transferred to broad gauge trucks at the frontier.

(1) Sleeping cars run between Madrid and :
Hendaye, Bilbao, Santander;
La Coruña, Gijon or Vigo;
Badajoz, Lisbon (via Marvo) ;
Cadiz and Granada, Algeciras and Malaga;
Cartagena, Alicante and Valencia;
Barcelona,

Also transverse services :
Barcelona, Saragossa, Hendaye and Bilbao;
Barcelona, Valencia, and a Valencia-Seville service;
Irun, Vigo or La Coruña,

TABLE 298.

LEADING DIMENSIONS OF THE INTERNATIONAL SLEEPING-CAR CO'S IBERIAN ROLLING STOCK.

| TYPE OF VEHICLE. | 1883 sleeping car. | Present day | | |
|---|---|---|---|---|
| | | Dining cars. | Sleeping cars. | Pullman cars. |
| Number of wheels. . . | 6 | 8 | | |
| Bogie wheel-base . . . | ... | 2.500 m. (8′ 2 7/16″). | | |
| Distance between bogie centres . . . . . | 6 000 m. (19′ 8 1/4″) | 14.500 m. (47′ 7″). | | |
| Length of body. . . . | 10 160 m. (33′ 4″) | 18.600 m. (61′ 5/16″) (*). | | |
| Do. underframe . . | ... | 20.300 m. (66′ 7 1/4″). | | |
| Do. over vestibules . | ... | 20.300 m. (66′ 7 1/4″). | | |
| Do. overall . . . . | 11 680 m. (38′ 4″) | 21.500 m. (70′ 6 1/2″). | | |
| Height above rail . . . | ... | 4.005 m. (13′ 1 3/4″). | | |
| Width inside. . . . . | ... | 2.802 m. (9′ 2 5/16″) | 2.822 m. (9′ 3 1/8″) | 2.814 m. (9′ 2 13/16″) |
| Do. outside . . . . | ... | 2.962 m. (9′ 8 5/8″) | 2.962 m. (9′ 8 1/4″) | 2.954 m. (9′ 8 1/4″) |
| Do. overall . . . . | ... | 3.100 m. (10′ 2″) | 3.100 m. (10′ 2″) | 3.100 m. (10′ 2″) |
| Number of passengers carried . . . . . | 18 | 48 | 1[illegible] | 24 |
| Tare . . . . . | 19.7 m. t. (19.4 Engl. t.) | 53.4 m. t. (52.5 Engl. t.) | 50.6 m. t. (49.8 Engl. t.) | 46.0 m. t. (45.3 Engl. t.) |
| Weight per passenger . | 1 094 m. t. (1 077 Engl. t.) | 1 112 m. t. (1 094 Engl. t.) | 3 162 m. t. (3 112 Engl. t.) | 1 916 m. t. (1 886 Engl. t.) |

(*) The Pullmans are 10 cm. (4″) shorter.

Possibilities offered by the broad gauge were taken advantage of in making the restaurant-car tables 1.050 m. (4′ 1/8″) wide while leaving a 0.634-m. (2′ 1″) corridor; in the sleepers the compartments were 1.98 m. (6′ 6″) wide and the corridors 0.80 m. (2′ 7 1/2″).

L-4. — **Electric traction.** — In addition to the Barcelona suburban lines, the *Norte* has electrified several of its steeply graded mountain sections.

Thus the section of the Puigcerda transpyrenean railway has been electrified from Ripoll (1). It was unnecessary to electrify the Canfranc transpyrenean line whose steepest part lies in France.

Conversely, the Pajares Pass section of the Leon-Gijon railway has been electrified, a distance of 62 km. (38.5 miles)

(1) The altitude of the stations located at over 1 000-m. (3 280′) above sea level is as follows :

| | | | |
|---|---|---|---|
| Plancias . . . . . | 1 084.00 m. (3 556′) | Alp-Urtg . . . . . | 1 182.85 m. (3 881′) |
| Tosas . . . . . | 1 407.00 m. (4 616′) | Caixans. . . . . | 1 107.94 m. (3 635′) |
| La Molina. . . . . | 1 420.22 m. (4 659′) | Puigcerda. . . . . | 1 146.64 m. (3 762′) |

Fig. 361. — Electrified Pajares Pass on the Leon-Gijon line of the *Norte Ry.*
Between the 54.967th and 50.392nd km. (34.5th and 31.8th mile), there is a difference in level of 910.32 m. (2 986′).
This section includes :

| | |
|---|---|
| Curves : 28.99 km. (18.56 miles). | In the open : 29.537 km. (18.4 miles). |
| Tangents : 25.976 km. (16.1 miles). | Tunnels (46.26 %), 25.430 km. (15.8 miles). |

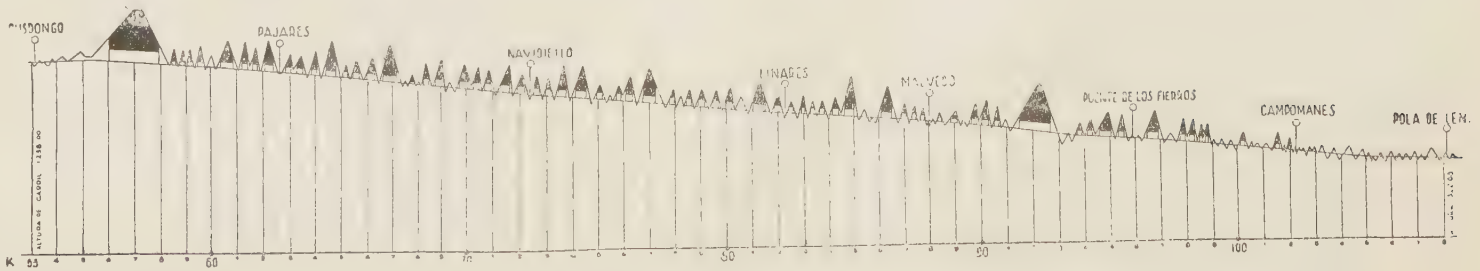



Fig. 362. — Gradient section, Pajares Pass, on the Leon-Gijon line *(Norte Ry)*.

between the Busdongo and Pola de Lena stations. This includes 68 tunnels totalling some 25 km. (15.5 miles), 151 bridges and viaducts, measuring altogether 865 m. (2 838′), and a particularly interesting loop which enables the railway to negociate some 100 m. (330′ 2″) difference in level (figs. 361 and 362) (1) downwards towards the coast.

On the Madrid-Irun main line, the Irun-Alsasua section, which climbs the secondary ranges of the Western Pyrenees and reaches the summit tunnel at a height of 610 m. (2 000′) above sea level, is also electrified at 1 500-v. D. C.

The electric locomotives (fig. 363) which must be able to negociate curves of 250 m. (12 1/2 chains) radius on the

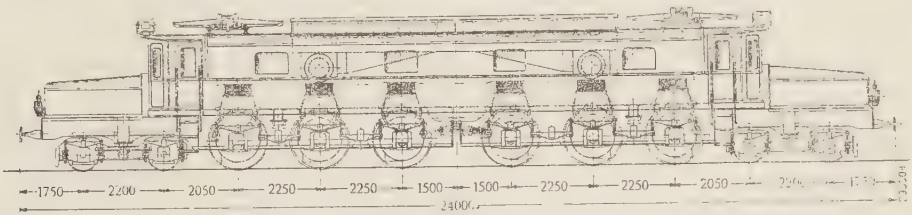



Fig. 363. — *Brown-Boveri* 2-Co-Co-2 locomotive, *Norte Ry.*

open line and 100 m. (5 chains) over points and crossings, and whose axle loads must not exceed 16 tons (2) can reach a maximum speed of 110 km. (68.3 miles) an hour.

L-5. — Railcars. — Most of the Spanish railway companies use railcars (called *autovias*) (fig. 364), but up to the present the fastest run only has an average speed of 76 km. (47.2 miles) an hour between Madrid (*Norte*) and Villalba. A number of *Ganz, Gaethom, Renault* and *Fiat* units, now on order, will have a maximum speed of 100 km. (62 miles) an hour.

In addition to single units, the *Norte* has ordered six articulated rakes, two being « de luxe » stock and two 2nd and 3rd-class coaches, each composed of four vehicles with four *Burmeister and Wain engines* (fig. 365) and two *Frichs* triplet 2nd and 3rd-class rakes.

The « de luxe » rakes are intended for the Spanish portion of the « Sud Express » and should reduce the journey to 9 hours 30 minutes, the average speed of 75 km. (46.6 miles) gaining 10 km. an hour (6.2 miles) on last summer's timetables. The maximum speed will be 120 km. (75 miles) an hour and the long gradients are to be climbed at 80 km. (50 miles) an hour.

The two other *Burmeister & Wain* rakes are intended for lines radiating from Madrid, and should save three hours between Madrid and La Coruña or Vigo and, on account of the Pajares gra-

(1) Stations located at over 1 000 m. (3 280′) above sea level :

| | | | |
|---|---|---|---|
| Pola de Gordon | 1 005.36 m. (3 298′) | Villamarin | 1 129.18 m. (3 705′) |
| Santa Lucia | 1 046.84 m. (3 434′) | Busdongo | 1 233.00 m. (4 045′) |
| Iglesias | 1 049.37 m. (3 442′) | Divisiora, km. 55.2 | 1 270.11 m. (4 167′) |
| Gifiera | 1 059.40 m. (3 476′) | Pajares | 1 144.35 m. (3 754′) |

(2) The driving wheels of these locomotives are 1.560-m. (5′ 1 7/16″) in diameter and the carrying wheels, 0.860-m. (3′ 25/64″). Their adhesive weight is 96 t. (94.5 Engl. tons) and total weight 145 t. (142.7 Engl. tons).

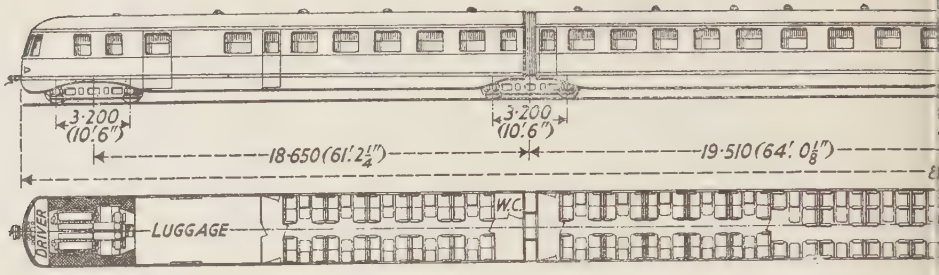



Fig. 365 (*). — *Burmeister & Wai*

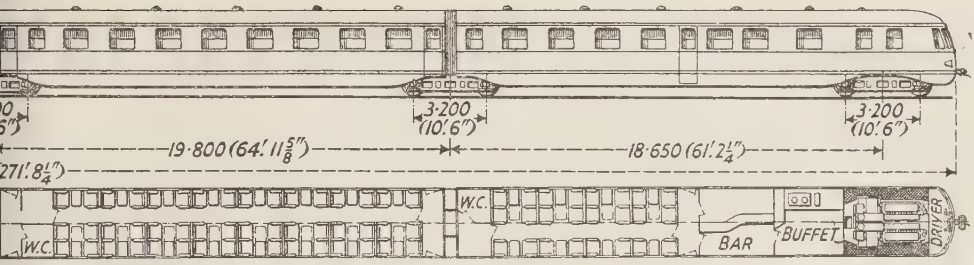
Fig. 364 (*). — Spanish lines worked by railcars.

dients, two hours only between Madrid and Gijon. The *Frichs* rakes are to run on the Madrid-Santander line.

The two types of Burmeister & Wain rakes (1) will contain 175 and 254 seats respectively, and weigh 134 t. (131.9 Engl.

(1) Each rake is fitted with four 365-H.P. motors. Each Frichs rake has four 275-H.P. engines.

(*) From *The Railway Gazette*, London.




sel quadruplet rake of the *Norte Ry.*

tons), i.e. 766 and 528 kgr. (1 689 and 1 664 lb.) tare weight per seat. The Frichs rakes will only weigh 117 t. (115.1 Engl. tons).

L-6. — **Speed.** — Iberian train speeds are low. Although some of the expresses are pompously called « rapidos » even when stopping at nearly every station, the only speeds of any account are to be found on the *Norte*, between Madrid and Irun, and in Portugal, between Lisbon and Oporto. It is interesting to note that the *Portuguese Co.*, which operates this service, has always maintained speeds approximately similar to our own, so that even before the War, Portugal ranked sixth in Europe from this point of view (fig. 354).

The double track between Lisbon and Oporto facilitates the services, though there are two 19-km. (11.8 miles) single-track breaks from Chão de Macas to Albergaria and along the final section, into Oporto (1).

With the exception of the double track between Lisbon and Cacen (21 km. = 13 miles) and that of the *Estoril Ry. Co.* (26 km. = 16.2 miles), this is the only double-track section in Portugal (2).

The Duero and the Tagus divide the Portuguese Railways into three systems, linked up by single-track bridges across them. The Duero is bridged between Oporto and Villa Nova de Gaia, and the Tagus at Muge, some way from Lisbon (3), which establishes rail connection between Oporto and Beja.

It is proposed to make a second connection between the same railways further east, between Porto Alegre and Souzel, and also, to build another bridge over the Tagus between Lisbon and Montijo.

In Spain, the mountainous nature of the whole country precludes any really fast running. In addition, apart from the *Norte*'s main line between Madrid and Irun, and the Madrid-Albacete (279 km. = 173.4 miles) and Madrid-Baides (124 km. = 77.1 miles) sections of the *M.Z.A.*, there are hardly any double-track lines; indeed, their totals reach but 790 km.

(1) Actually the line from Lisbon joins at Campanha, beyond Oporto, the railway on to the northern frontier, and backs as a single-track line into Oporto station. The two lines merge just before reaching Campanha.

(2) The southern Portuguese railway system starts from the Lisbon Barreiro station, which terminal is situated on the southern bank of the Tagus, while the central system has a terminal at Ricio, on the northern bank. Ferries maintain a 35-minute service between T. de Paço on the northern bank and the station of Barreiro on the southern.

(3) This connection is 70 km. (43.5 miles long between Setil (63th km. of the Oporto line) and Vendas Novas (57th km. of the Beja line).

TABLE 299

NOTEWORTHY SPANISH AND PORTUGUESE TRAIN RUNS.

(See fig. 354).

(Non-stop runs are shown in *heavy* type).

| RUNS. | COMPANIES. | Distance. | | Time of departure. | Time spent. | Number of stops. | Speed. | | — |
|---|---|---|---|---|---|---|---|---|---|
| | | Km. | Miles. | | | | Km./h. | Miles/h. | |
| Madrid N.-Avila-Irun (Hendaye). . . . . | Norte. | 631 | 392.1 | 10.30 a.m. | 9.45 | 14 | 64.7 | 40.2 | Rapido 13. |
| Madrid N.-Villalba . . . . | Do. | 38 | 23.6 | **5.15** p.m. | **0.30** | ... | **76.0** | **47.2** | Tranv. A 2013. |
| Avila-Medina del Campo. . | Do. | 86 | 53.4 | **12.40** p.m. | **1.00** | ... | **86.0** | **53.4** | Rapido 13. |
| Villalba-Avila-Medina del Campo. . . . . | Do. | 162 | 100.7 | 11.06 a.m. | 2.34 | 2 | 72.5 | 45 | Do. |
| Villalba-Segovia-Medina del Campo . . . . . | Do. | 156 | 96.9 | 5.45 p.m. | 2.41 | 14 | 58.1 | 36.1 | Tranv. A 2013. |
| Medina del Campo-Valladolid N. . . . . | Do. | 42 | 26.1 | **2.22** p.m. | **0.33** | ... | **76.4** | **47.5** | Rapido 11. |
| Valladolid-Venta de Baños. | Do. | 37 | 23.0 | **2.20** p.m. | **0.27** | ... | **81.5** | **50.6** | Rapido 37. |
| Venta de Baños-Burgos C. | Do. | 84 | 52.2 | **2.49** p.m. | **0.56** | ... | **90.0** | **55.9** | Rapido 13. |
| Zumarraga N.-Tolosa . . . | Do. | 40 | 24.9 | **6.59** p.m. | **0.30** | ... | **80.0** | **49.7** | Do. |
| Madrid-Leon-Gijon-Norte . . | Do. | 577 | 358.5 | 10.15 a.m. | 11.45 | ... | 48.0 | 29.8 | Rapidos 11, 911, 411, 511. |
| Leon-Gijon. N. . . . . | Do. | 170 | 105.6 | 5.45 p.m. | 4.15 | 18 | 40.0 | 24.9 | Rapido 511. |
| Busdongo-Ujo N. . . . . | Do. | 62 | 38.5 | 70.1 p.m. | 1.24 | 5 | 44.2 | 27.5 | Do., electric. |
| Madrid-Lerida-Saragossa-Barcelona N. . . . . | Norte and M.Z.A. | 713 | 443.0 | 9.00 a.m. | 14.30 | 28 | 44.1 | 27.4 | Rapido 215. |
| Madrid Atocha-Caspe-Barcelona | M.Z.A. | 685 | 425.6 | 10.15 p.m. | 11.41 | 5 | 58.7 | 36.5 | «de luxe» train 804. |
| Madrid-Jadraque . . . . | Do. | 105 | 65.2 | » | **1.39** | ... | **63.6** | **39.5** | Do. |
| Madrid-Arcos de Jalon . . | Do. | 183 | 113.7 | **R6.36** a.m. | **2.54** | ... | **63.1** | **39.2** | «de luxe» train 805. |
| Madrid Del.-Valencia de Alcantara-Lisbon . . . . . | Oeste. | 665 | 413.2 | 10.00 a.m. | 11.55 | ... | 55.4 | 34.4 | Rapido 2. |
| Madrid Delicias-Valencia de Alcantara . . . . . | Do. | 403 | 250.4 | » | 8.00 | ... | 50 4 | 31.3 | Do. |
| Do. (Villaverde)-Griñon. . . | Do. | 23 | 14.3 | 10.09 a.m. | 0.34 | ... | 40.6 | 25.2 | Do. |
| Madrid Atocha-Badajoz-Lisbon | M.Z.A. | 799 | 496.5 | ... | ... | ... | ... | ... | ... |
| Madrid (Villaverde bajo)-Algodor. . . . . | Do. | 54 | 33.6 | 10.05 a.m. | 0.55 | ... | 58.9 | 36.6 | Expreso limitado 600. |
| Madrid Atocha-Seville . . . | Do. | 573 | 356.0 | 10.10 p.m. | 10.10 | 21 | 52.0 | 32.3 | Expreso 404. |
| Madrid At.-Alcazar-S. Juan | Do. | 149 | 92.6 | » | **2.14** | ... | **66.7** | **41.4** | Do. |
| Madrid Aranjuez . . . . | Do. | 49 | 30.4 | **8.00** a.m. | **0.43** | ... | **68.4** | **42.5** | Autovia 4530. |
| Madrid-Cordoba-Malaga. . . | M.Z.A. and And. | 635 | 394.6 | 8.30 p.m. | 11.40 | ... | 54.4 | 33.8 | Expresos405-506 |
| Madrid-Getafe-Toledo. . . . | M.Z.A. | 77 | 47.8 | 8.15 a.m. | 1.34 | 9 | 40.5 | 25.2 | Autovia 4620. |
| Madrid-Aranjuez Toledo. . . | Do. | 91 | 56.5 | 9.10 a.m. | 1.35 | 4 | 47.4 | 29.5 | Expreso 602. |

Table 299 (*Contd*).

| Runs. | Companies. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Number of stops. | Speed. Km./h. | Speed. Miles/h. | — |
|---|---|---|---|---|---|---|---|---|---|
| Madrid At.-La Encina-Valencia. | M.Z.A. and Norte. | 490 | 304.5 | 10.15 p.m. | 9.45 | 14 | 50.3 | 31.3 | Expreso Correio 510. |
| Alcazar de S. Juan-Albacete | M.Z.A. | 130 | 80.8 | 1.39 a.m. | 2.00 | ... | 75.0 | 46.6 | Do. |
| CROSS COUNTRY LINES. | | | | | | | | | |
| Barcelona Fr.-Port-Bou | M.Z.A. | 167 | 103.8 | 2.00 p.m. | 2.55 | 5 | 57.3 | 35.6 | Expreso 202. |
| Barcelona Fr.-Empalme | Do. | 70 | 43.5 | » | 1.12 | — | 58.4 | 36.3 | Do. |
| (Barcelona N.) Saragossa-Bilbao N. | Norte. | 344 | 213.8 | 3.35 p.m. | 7.10 | 20 | 48.0 | 29.8 | Rapido 815. |
| (Madrid) Saragossa-Canfranc. | Do. | 173 | 107.5 | 3.30 p.m. | 3.20 | 5 | 51.6 | 32.1 | Rapidos 201-241. |
| Saragossa-Zuera. | Do. | 26 | 16.2 | » | 0.23 | — | 67.8 | 42 1 | Do. |
| Barcelona Termine-Valencia N.-Albacete-Alcazar de S. Juan-Baleza-Cordoba-Seville. | M.Z.A., Norte and M.Z.A. | 1 184 | 735.7 | 12.43 p.m. | 24.17 | 77 | 48.1 | 29.9 | Rapido. |
| Granada-Murcia-Alicante | And & Comp. | 411 | 255 4 | 7.30 a.m. | 12.55 | ... | 31.8 | 19.8 | Tren directo. |
| Granada-Murcia-Cartagena | And., Comp. and M.Z.A. | 401 | 249.2 | » | 11.55 | ... | 33.5 | 20.8 | Expresos 500-504. |
| Valencia-Caminreal-Saragossa | Cent.Aragon. | 350 | 217.5 | 7.05 a.m. | 7.10 | 20 | 48.8 | 30.3 | Rapidos 2-101. |
| (Irun) Medina del Campo-F. de Oñoro (Lisbon) | Oeste. | 202 | 125.5 | 4.25 a m. | 4.54 | 7 | 41.2 | 25.6 | «Sud Express». |
| PORTUGAL. | | | | | | | | | |
| Lisbon Ricio-Oporto | Portuguese. | 349 | 216.9 | 2.10 p.m. | 5 07 | 5 | 68.4 | 42.5 | Rapido 53. |
| Lisbon-Entroncamento. | Do. | 113 | 70.2 | » | 1.13 | — | 92.9 | 57.7 | Do. |
| Entroncamento-Coimbra | Do. | 111 | 69 | 3.24 p.m. | 1.28 | — | 75.7 | 47 | Do. |
| Aveiro-Vila Nova de Gaia | Do. | 59 | 36.7 | 5.55 p.m. | 1.04 | — | 55 3 | 34.4 | Do. |
| Oporto-Barca d'Alba | Do. | 203 | 126.1 | 12.10 p.m. | 4.55 | 10 | 41 3 | 25.7 | Rapido 155. |
| Lisbon-Marvao (Madrid) | Do. | 246 | 152.9 | 8.40 a.m. | 4.21 | 8 | 56.7 | 35.2 | Rapido 51-151. |
| Lisbon-T. Paço-Funcheira | Do. | 218 | 135.5 | 9.20 a.m. | 4.02 | 6 | 53.6 | 33.3 | Rapido 951. |
| Casa Branca-Cuba | Do. | 47 | 29 2 | 11 20 a.m. | 0.36 | — | 78.4 | 48.7 | Do. |
| Cuba-Beja | Do. | 16 | 9.9 | 11.56 a m. | 0.12 | — | 80.0 | 49.7 | Do. |
| Pampilhosa-Villa Formosa | Beira-Alta. | 202 | 125 5 | 5.12 p.m. | 4.00 | 10 | 50.5 | 31.4 | «Sud Express». |

(490.8 miles) for the *Norte* and 791 km. (491.5 miles) for the ***M.Z.A.***

On the other hand, Barcelona is an important secondary centre and a terminus of many services, both towards the Pyrenees and towards the west (Bilbao) and south.

There is also a particularly interesting cross country service, from Barcelona to Valencia and Seville, through expresses, after covering the 92 km. (57.2 miles) of the ***M.Z.A.*** (*) following the *Norte*'s metals as far as La Encina (beyond Valencia), and the ***M.Z.A.*** beyond, by their roundabout Albacete route, instead of the

(*) From Barcelona to Tarragona.

TABLE 300.

FASTEST AND LONGEST NON-STOP RUNS.

| RUNS. | Distance. Miles. | Distance. Km. | Time of departure. | Time spent. | Speed. Km./h. | Speed. Miles/h. | — |
|---|---|---|---|---|---|---|---|
| FASTEST TRAINS. | | | | | | | |
| **Norte.** | | | | | | | |
| (Madrid) Venta de Baños-Burgos C. (Irun) | 84 | 52.2 | 2.49 p.m. | 0.56 | 90.0 | 56.0 | Rapido 13. |
| Avilla-Medina del Campo | 86 | 53.4 | 12.40 p.m. | 1.00 | 86.0 | 53.4 | Do. |
| Valladolid-Venta de Baños | 37 | 23.0 | 2.20 p.m. | 0.27 | 81.5 | 50.6 | Rapido 37. |
| Burgos C.-Miranda de Ebro | 96 | 59.7 | 3.50 p.m. | 1.10 | 77.1 | 47.9 | Rapido 13. |
| Medina del Campo-Valladolid | 42 | 26.1 | 2.22 p.m. | 0.33 | 76.4 | 47.5 | Rapido 11. |
| Madrid N.-Villalba | 38 | 23.6 | 5 15 p.m. | 0 30 | 76.0 | 47.3 | Autovia 2013. |
| **M. Z. A.** | | | | | | | |
| (Madrid) Alcazar de S. Juan-Albacete. | 130 | 80.8 | 1.39 a.m. | 2.00 | 75.0 | 46.6 | Expreso 510. |
| Alcazar de S. Juan-Manzanares | 49 | 30.4 | 10.50 p.m. | 0.40 | 73.5 | 45.7 | Expreso 406. |
| **Portuguese Rys.** | | | | | | | |
| Lisbon-Entroncamento. | 113 | 70.2 | 2.10 p.m. | 1.10 | 92.9 | 57.7 | «Sud Express» 53 |
| (Lisbon) Cuba-Beja. | 16 | 9.9 | 11.56 a.m. | 0.12 | 80.0 | 49.7 | Rapido 951. |
| (Lisbon) Casa Branca-Cuba. | 47 | 29.2 | 11.20 a.m. | 0.36 | 78.4 | 48 7 | Do. |
| (Lisbon) Entroncamento-Coimbra. | 111 | 69.0 | 3.24 p.m. | 1.28 | 75.7 | 47.0 | «Sud Express« 53 |
| LONGEST RUNS. | | | | | | | |
| **M. Z. A.** | | | | | | | |
| (Madrid) Saragossa Sep. Mora la Nueva | 191 | 118.7 | 3.50 a.m. | 3.13 | 60.0 | 37.3 | « de luxe » 804. |
| Madrid Atocha-Arcos de Jalon | 183 | 113.7 | R6.36 a.m. | 2.54 | 63.1 | 39.2 | « de luxe » 805. |
| (Madrid) Arcos de Jalon-Saragossa Sep. | 158 | 98.2 | 1.27 a.m. | 2.13 | 71.2 | 44.2 | « de luxe » 804. |
| Madrid Atocha-Alcazar de S. Juan (Seville) | 149 | 92.6 | 10.10 p.m. | 2.14 | 66.7 | 41.4 | Expreso 404. |
| (Madrid) Alcazar de S. Juan-Albacete. | 130 | 80.8 | 1.39 a.m. | 2 00 | 75.0 | 46.6 | Expreso 510. |
| Madrid Atocha-Jadraque | 105 | 65.2 | 10.15 p.m. | 1.39 | 66.6 | 41.4 | « de luxe » 804. |
| (Madrid) Reus M.Z.A.-Barcelona (Pas. de Gr.) | 101 | 62.8 | 8.14 a.m. | 1.31 | 66 6 | 41.4 | Do. |
| **Norte.** | | | | | | | |
| (Madrid N.) Avila-Medina del Campo. | 86 | 53.4 | 12.40 p.m. | 1.00 | 86 0 | 53.4 | Rapido 13. |
| (Madrid N.) Venta de Baños-Burgos C. | 84 | 52.2 | 2.49 p.m. | 0.56 | 90.0 | 56.0 | Do. |
| **Portuguese Rys.** | | | | | | | |
| Lisbon-Entroncamento | 113 | 70.2 | 2.10 p.m. | 1.10 | 92.9 | 57.7 | «Sud Express» 53 |
| (Lisbon) Entroncamento-Coimbra. | 111 | 69.0 | 3.24 p.m. | 1.28 | 75.7 | 47.0 | Do. |

Table 301.

LENGTH OF LINES RUN OVER AT VARIOUS OVERALL SPEEDS.

| COMPANY. | System, km. (miles). | Speeds. 90 to 94.5 km./h. (56 to 59 m.p.h.) | 80 to 89.9 km./h. (50 to 55.9 m.p.h.) | 70 to 79.9 km./h. (44 to 49.9 m.p.h.) | 60 to 69.9 km./h. (38 to 43.9 m.p.h.) | Under 60 km./h. (Under 38 m.p.h.) | Percentage of lines having no trains whose overall speed reaches 60 km./h. (38 m. p. h.) |
|---|---|---|---|---|---|---|---|
| SPAIN. | | | | | | | |
| Norte | 3 711 (2 306) | 84 (52.2) | 163 (101.3) | 332 (206.3) | 424 (263.5) | 2 708 (1 682.7) | 73 |
| M.Z.A. | 3 675 (2 284) | ... | ... | 421 (261.7) | 1 036 (644) | 2 218 (1 378.3) | 60 |
| Andalusian | 1 646 (1 023) | ... | ... | ... | 153 (95) | 1 493 (928) | 90 |
| Western | 1 598 (993) | ... | ... | ... | ... | 1 598 (993) | 100 |
| Central Aragon. | 420 (261) | ... | ... | ... | 116 (72) | 304 (189) | 70 |
| PORTUGAL. | | | | | | | |
| Portuguese Rys. Co. | 3 443 (2 139) | 113 (70) | 16 (10) | 158 (98) | 125 (78) | 3 031 (1 883) | 72 |
| Beira-Alta | 253 (157) | ... | ... | ... | 78 (48) | 175 (109) | 69 |

shorter one from Alicante to Seville over the *Gt. Southern* and *Andaluces Rys.*

This transverse line is therefore similar in character to the Liége-Tournai and Dieppe-Bordeaux lines, with the difference that the Spanish « rapido » stops 77 times on the way and its average speed is exceedingly low.

In Table 299, will be found interesting Iberian services, but in order to avoid repetition, we only quote a few typical examples of « rapidos » between Madrid and the coast. The great number of intermediate stops should be noted.

We have given a rather more complete list in the case of the non-stop runs from Madrid, which only concern the *Norte* and *M.Z.A.*, as the *Nacional del Oeste*'s longest non-stop run is only 26 km. (16.2 miles) to Griñon, and this at less than 50 km. (31 miles) an hour.

We have also given the mileage of the chief alternative routes, and as the case may be, quoted expresses running over them. After the Madrid lines, will be found the interesting provincial routes, then the Portuguese ones.

Table 300 gives the fastest trains and longest non-stop runs. The Spanish *Norte* and *Portuguese* Rys. head the former list, the *M.Z.A.* the second.

In conclusion, table 301 gives the mileage of each company for the different average speeds, as well as the percentage of Railways having no average speed reaching 60 km. (37 miles).

*(To be continued.)*

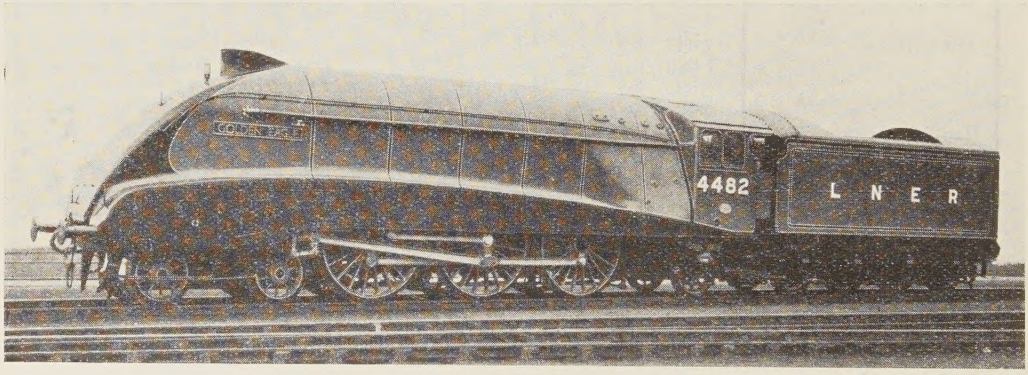
# MISCELLANEOUS INFORMATION.

[ 621. 132.3 (.42) ]

## 1. — 4-6-2 streamlined express passenger locomotive « Golden Eagle », London and North Eastern Railway.

We publish hereafter, by courtesy of Sir H. Nigel GRESLEY, Chief Mechanical Engineer, London and North Eastern Railway, a photograph of Engine No. 4482 « Golden Eagle », the first of a new series of streamlined express passenger locomotives.

These engines have similar dimen-




sions to those of the « Silver Link » type locomotives, particulars of which have been given in the November 1935 number of this *Bulletin*, p. 1299, but they are finished in L. N. E. R. standard green.

[ 656. 25 (.42) ]

## 2. — Resignalling of the Northallerton-Darlington Line.

The London and North Eastern Railway have awarded to the Westinghouse Brake and Signal Co., Ltd., the contract for the resignalling of the Northallerton to Darlington Line. This contract, which is the largest to be placed in Great Britain for many years, includes the supply and installation of searchlight signals over some 17 miles of line, of which approximately 14 miles include complete power signalling on two, three, and four tracks, with A. C. track circuiting throughout, and also resignalling at Northallerton and Darlington South.

# ERRATA.

*Bulletin*, December 1936 number.

**Recent improvements in steam locomotives** of the usual type and tests of new designs... **Testing locomotives** at locomotive experimental stations... Report (*Great Britain, Dominions and Colonies, America, China and Japan*), by Sir H. Nigel GRESLEY.

— Page 1306/16 — (3 and 4, heavy type).

*Instead of :* New apparatus for cleaning smoke tubes, and if any deterioration of tube plates from the use...

*Read :* New apparatus for cleaning smoke tubes, and if any deterioration of tubes and tube plates from the use...

— Page 1316/26 — (Top table, *Baltimore & Ohio*). — Life of ring, miles :

| | | | | | |
|---|---|---|---|---|---|
| *Instead of* | Passenger . . . | No test. | *Read* | Passenger . . . | 80 000. |
| | Freight . . . . | 80 000. | | Freight . . . . | No test. |

— Page 1317/27 — Bottom table, *Great Indian Peninsula Ry.* — *Form of cut :*

*Instead of :* Diagonally at 45°,
*Read :* Diagonally at 75°.

— Page 1323/33 — (Lower table, Southern Ry.) (II) Valve gears...
*Instead* of : ... (Nil), *Read :* 25 to 30 %.

— Page 1327/37 — White metal analysis (*Central Argentine Ry.*).

| | | | | | |
|---|---|---|---|---|---|
| *Instead of* | Lead . . . . . | 5.5 | *Read* | Lead . . . . . | — |
| | Antimony . . . . | 11.5 | | Antimony . . . . | 5.5 |
| | Copper . . . . . | 83.0 | | Copper . . . . . | 11.5 |
| | Tin. . . . . | — | | Tin . . . . . | 83.0 |

— Page 1329/39 — Remarks column *(Great Indian Peninsula Ry).*
*Instead of :* No. 3 alloy, grease lubricated...
*Read :* No. 3A alloy, grease lubricated...

— Page 1340/50 — Appendix D/3 : Description correct, but illustration should be that shown under D/4.

— Page 1341/51 — Appendix D/4 : Description correct, but illustration should be that shown under D/3.

— Page 1364/74 — Appendix L/14.
*Instead of :* 5 X P 4-6-4... engine,
*Read :* 5 X P 4-6-0... engine.

— Page 1367/77 — First column, 4th line down :
*Instead of :* three-cylinder 4-8-4 suburban tank engine...
*Read :* three-cylinder 4-6-4 suburban tank engine...